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ELEMENTS

OF

MINERALOGY.

BY

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THE THIRD EDITION.

IN TWO VOLUMES.

VOL. I.

EARTHS AND STONES.

LONDON:
PRINTED FOR J. MACKINLAY, 87, STRAND.
1810.

London: Printed by B. McMillan,
Bow Street, Covent Garden.

PREFACE

TO THE SECOND EDITION.

NUMEROUS and rapid as have been the improvements made in the branches of natural knowledge chiefly cultivated in France and England since the year 1784 (that in which the first edition of these Elements has appeared), those that have fallen to the share of Mineralogy, the branch with us least attended to, have equalled and kept pace with them. In the preceding decennial period, from 1774 to 1784, Mineralogy may be said to have for the first time assumed its rank among the sciences, its simplest elements having been for the most part discovered, and established within that period, its leading distinctions ascertained, and the great art of resolving the most complex into the simplest substances not barely improved, but in a manner created. In the succeeding period, from 1784 to the present year, our knowledge respecting each of these objects has been still farther extended; precise lines of discrimination have been traced even in the minuter sub-divisions of the science; the gross indications of the unassisted senses, freed from their attendant fallacies, have been pressed into its service; the more refined chemical

tests

tests still farther perfected, have been rendered more conclusive; many new species brought to light; the catalogue of the supposed elementary substances nearly completed; and the great art of analysis, extended far beyond its former limits, now nearly reaches the precision of an algebraic formula.

Having thus summarily marked the progress of the art, I should consider it as an act of injustice to suppress the illustrious names to whom we are indebted for these acquirements; if in the former period a Scheele and a Bergman challenged our gratitude and admiration, in the present, these sentiments are justly due to a Klaproth and a Werner; to the former we owe the most accurate, subtle, and refined analyses; to the latter, the selection, depuration, and judicious application of the external characters of fossils; the former detects the internal principles, the latter depicts the substances to which those principles belong; if the researches of the former have in many cases led him to the discovery of new and unsuspected elements, those of the latter, by a happy comparison of the habitudes of adjacent fossils, have led him to the true designation of their origin; by the joint efforts of both, as far as these investigations have hitherto reached, not only the nature and properties of minerals singly taken, but also their relations, connections, and dependencies on each other, have received the fullest and most satisfactory illustration.

If from the prospect of these improvements we now turn our attention to the causes of this unexampled progress, we may easily deduce them from the evident change, I may almost say revolution, that has taken place in the public mind within these last ten years. Nations in the full enjoyment of the most considerable natural advantages, extent of territory, fertility of soil, benignity of climate, have beheld within that short period, with mixed sentiments of astonishment, envy, and regret, that superiority of opulence, resources, and power, conferred by an unremitted and successful application of the mathematical and physical sciences on countries to whom nature had in every respect been much less liberal; they observed the connexion of mineralogy in particular, not only with subterraneous substances to which it was long erroneously supposed exclusively confined; but with all the inorganic matter that forms the earth's surface, and consequently, with agriculture, medicine, and the raw materials, or necessary instruments of all manufactures that supply either the necessaries, comforts, or luxuries of human life; in consequence of these observations, all the European nations zealously concurred in paying a fuller attention to its cultivation; many have been immediately rewarded by the discovery of substances within their own territories, before imported with great difficulty and expence from other countries*, mineralogical voyages were every where undertaken, mineralogical collections, if not first formed, became more numerous, and far more scientifically arranged; treatises on this object have appeared in all languages; Germany, in every instance, outpassed even its former exertions, and still continues to uphold its ancient superiority; there a mineralogical society has been formed, whose branches extend to all parts of the globe, and of whose transactions some volumes have already appeared; similar, though less extensive associations have taken place in other countries; eminence in this science has at once been rewarded and multiplied by public esteem, civil honours, and emoluments; and thus every motive to human industry happily applied.

It will, I suppose, be readily granted, that the multifarious stock of information, thus promiscuously accumulated in several countries, conveyed in various languages, and not always presented in the most intelligible manner, could not easily be collected, digested, and arranged, or in many cases readily understood; such, indeed, were the difficulties attendant on such an undertaking, that, were I not encouraged by an event as favourable as unexpected, I should despair of attempting it with any prospect of success; the event I allude to is the acquisition of the *Leskean* collection of fossils, the most perfect monument of mineralogical ability now extant; that the possession of this cabinet should escape the vigilance of the most learned nations and fall to the lot of Ireland, hitherto so inattentive to matters of this nature, was little to be expected; through the active zeal, however, of two of its most enlightened patriots*, and the influence secured to them by former services of the most essential nature, the sums requisite for its purchase, and for building a repository to receive it, were obtained; hitherto its treasures have been unveiled only to my eyes; the time, however, approaches, in which it will be laid open to the inspection of the curious, and thence we may date the diffusion of exact mineralogical knowledge, not only in this, but perhaps in the neighbouring countries. I say exact, for among several intelligent foreigners who have lately passed into this kingdom, to whom I exhibited a few specimens of various fossils, I met none, except those of the Wernerian school, who could truly distinguish them.

---

* As cobalt, coal, fuller's earth, tarras, &c.

From the inspection of this cabinet, the use I was permitted to make of its specimens, and the well-digested catalogue annexed to it, I derived numerous advantages, being enabled to rectify false descriptions, determine the ambiguous, enlarge the defective, discriminate or appropriate, as the case might be, substances to which either the same or different denominations had commonly heretofore been erroneously applied, and even to add new descriptions, suggest new distinctions, and supply additional characters or tests of substances nearly bordering on each other: for this purpose I scrupulously examined the specific gravities of most of the substances mentioned in the following work, as well as their fusibility in various degrees of heat by the help of Mr. Wedgwood's pyrometer; and to extract from these all the light they were capable of affording, I made many new experiments on the fusibility of various combinations of the simple earths, to the advantage as I expect of the arts of pottery and vitrification.

---

* Right. Hon. John Forster, Speaker of the House of Commons, and the Right Hon. William Burton Cunningham.

The reader will probably be desirous to know on what grounds the authority of the Leskean cabinet rests, on which I so much rely; these I the more readily undertake to explain, as they lead me to a summary description of the various parts of which it consists, and the *marks* by which they are distinguished in the quotations in which I refer to them.

Previous to the year 1780, Mineralogy, though tolerably understood by many as an art, could scarce be deemed a science, being, for want of precise definitions of its objects, incapable of communication: the *same* substance, from some slight variation of appearance,

ance, was often denoted by different names, and *different* substances by the same name; its descriptive language, was, for the most part, arbitrary, vague, and ambiguous, each author using that which seemed to him best to answer his purpose; to obviate the confusion thence ensuing, chemical tests were applied; but even these were found in many cases insufficient, unless the substances exposed to them were thoroughly analyzed; a work of great difficulty, involving an intolerable length of time, and, when executed, demonstrative only of the individual substance to which it was applied. When any new specimen occurred, it might still be questioned whether it was or was not of the same nature as that already analyzed; recourse must then have been had to description, and thus the same inconveniencies recurred. After many ineffectual attempts to obviate these difficulties, by Linnæus, Peithner, and others, descriptive language was at last reduced to as much precision as it was capable of receiving, by Mr. Werner in 1774, and by the union of external characters *thus described*, with the results of chemical analyses, the *denominations* of most of the earths and stony substances then known, were finally settled by the same illustrious author in his Notes on Cronstedt, published in 1780*.

---

* Since that time Mr. Weaver has published an excellent tract on External Characters, and after him Mr. Jamieson. Mr. Hauy's has also much merit.

All the mineralogical collections, therefore, formed before that year, or even since, if arranged on other principles, are necessarily in many respects defective and erroneous.

Of the many excellent disciples formed by Mr. Werner, Leske, the framer of the present collection, was one of the earliest and most eminent; upon Werner's principles, and with his assistance, it was arranged between the years 1782 and 1787. Upon the decease of Mr. Leske, it was revised, corrected, and enlarged, by Mr. Kärsten, also a disciple of Mr. Werner's, and, next to him, perhaps the most acute and judicious mineralogist now existing: to him we owe the catalogue that accompanies the cabinet, and which, like this, is divided into five parts; the first, destined to convey the knowledge of the descriptive language, by exhibiting to the senses the characters described, is called the *characteristic* part, and is marked K; it consists of 580 specimens. The second part contains the *systematic* or oryctognostic collection, as it is called, and thence marked O; in this, the simpler fossils are distinguished under their Genera and Species, according to the method then followed by Mr. Werner; it exhibits 3268 specimens. The third part is called *geognostic* or geological, and thence is marked G, presenting the substances found in primæval, stratified, aluvial, and volcanic mountains, and containing perhaps the completest collection of petrifactions now extant; it consists of 1100 specimens. The fourth is destined to present specimens of the fossils found in different parts of the globe, proceeding, in an orderly series, from America to Asia, Europe, and Africa, and hence marked S; this, though it presents 1909 specimens, is necessarily the most defective, being in reality the bare outline of an immense plan, which can be completed only by national opulence, when all parts of the globe have been thoroughly explored, and Mineralogy extended to the utmost limits of ideal perfection; yet, imperfect as it is, it may be, to persons who have already made some progress in mineralogical knowledge, by far the most instructive, as it discovers an immense variety of substances of the same denomination, so multifariously disguised that it required all the sagacity of a Kärsten to elucidate and distinguish them: this part is particularly rich in German fossils, more especially the Saxon, with the references to the accounts of Charpentier, and Leske's mineralogical travels, in which they are more minutely described; here also we meet those *suspicious* fossils found in the diocese of Fulda, and on the borders of the Rhine, which many have supposed to be volcanic, with references to Voight, who has described them under names alluding to this origin. The fifth is called the *œconomical* collection, being formed of 474 specimens of the fossils used in various arts and manufactures, as architecture, sculpture, agriculture, jewellery, colouring, dying, clothing, pottery, glazing, enamelling, polishing of metals, furnace building, medicine, metallurgy, &c.

The whole cabinet contains 7331 specimens, and as (except that of the mineralogical school at Fribourg, and that of Mr. Pabst Von Ohain) it is the only one that contains specimens of almost every known species, arranged on fixed principles, and, at least for the most part truly denominated, its value may thence be estimated. That of Mr. Pabst contains only 6673 specimens.

Complete as this collection may appear, in comparison with all others hitherto formed, it necessarily partakes of the imperfect state of the science itself; and being the work of an individual, far removed from opulence, and some years dead, it is defective with respect to some substances lately discovered, and also in English, alpine, and volcanic specimens; of these last, however, at least of those of Vesuvius, the Royal Irish Academy possesses a very ample and well-digested series through the bounty of the Reverend Mr. Graydon, not bought up from ignorant or swindling dealers at Naples, but painfully collected by himself on that mountain, and the neighbouring territory: his uncommon sagacity in tracing appearances to their true causes, and the knowledge he acquired through a careful attention to local circumstances, have enabled him to deduce the intricate filiation and connection of these productions with all the satisfaction and certainty that the nature of the subject can admit.

The present edition of these Elements of Mineralogy being grounded on a foundation so very different from the former, necessarily assumes a very different form, being much more copious, and, as I hope, infinitely more perfect. The external characters (crystallization excepted) are enumerated and described with very little variation from Mr. Werner's tract on that subject; some new Genera, and many new Species, are introduced, the analysis by different persons annexed. Not servilely addicted to any system, I have taken the liberty, when I thought it necessary, of framing new distinctions, and even of introducing a new class; I have also added the description of some Irish fossils, which appeared not to have been known in other countries. Volcanic productions, that in the former edition were but slightly mentioned, will here be found minutely considered, and the origin of basalt fully discussed. I have also treated of the analysis of Earths and Stones much more at large than before, and impartially examined those already made; in a word, I hope I have faithfully represented the present state of the Science.

Dublin, Jan. 1, 1795.

ERRATA.

The reader is requested to advert to the following errors, in the wrong paging of two sheets of this volume.

For page 373, beginning, " my experiments," to p. 388, ending " as," *read*, 273, &c. to 288.

For p. 405, beginning " porphyry," to p. 420, ending " sort," *read*, 305, &c. to 320.

To enable the reader more readily to distinguish these erroneous folios from similar ones in a subsequent part of the volume, an asterisk (*) is put to them in the contents.

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ELEMENTS

OF

MINERALOGY.

MINERALOGY, as distinct from *Natural History*, is the art of distinguishing mineral substances from each other.

All bodies found in or on the earth, and not of vegetable or animal origin, are called Minerals.

The whole complex system of minerals, called the *Mineral Kingdom*, is usually divided into four parts: 1. Earths and Stones. 2. Salts. 3. Inflammables. 4. Metallic Substances. Of each of which I shall treat in the same order.

PART I.

OF EARTHS AND STONES.

THE term earth, denotes a tasteless, inodorous, dry, brittle, uninflammable substance, whose specific gravity does not exceed 4,9, and gives no tinge to borax in fusion. Yet quick-lime is usually called an earth, though it has a pungent taste, and is very perceptibly soluble in water, and some sorts lately discovered in very considerable proportion: so also is *Gypsum*, which is also in some degree soluble in water, and even contains a saline principle: perhaps, in strictness, there is no earth which is not in some degree soluble. However, since a line must be drawn between salts and earths, I think it should begin where solution is scarcely perceptible; salts terminating, and earths, in strictness, commencing, where the weight of water requisite for the solution exceeds that of the solvend 1000 times. But, not to depart too widely from the commonly received import of words that are in constant use, substances that require 100 times their weight of water to dissolve them, and have the other sensible appearances of earths, may be so styled in a loose and popular sense.

Stones differ from earths principally in cohesion and hardness, and therefore are included under the same general name: yet diamond is also called a stone, though it probably contains no earth of any kind.

Most earths are soluble in some acid or other, and many in all acids: the Prussian alkali can precipitate none of them from these solutions: whereas, it precipitates all metallic substances from their acid solvents*. This forms a distinct line of separation between earths and metallic substances. The exception, formerly made in favour of barytic earth, is now found to have arisen from a mistake.

---

* Except Platina.

CHAP. I.

OF SIMPLE EARTHS, THEIR NUMBER, AND CHARACTERS.

SIMPLE earths, are those which are incapable of being converted or analyzed by any means hitherto known, either into each other, or into any other substance.

Of these we have nine: the *Calcareous*, the *Barytic*, the *Magnesian* or *Muriatic*, the *Argillaceous*, the *Siliceous*, the *Scottish* or *Stronthian*, the *Jargonic*, the *Sydneian*, and the *Adamantine*.

Of these, the five first are by far the most general, most of the earths and stones hitherto examined being resolvable into them. Next to these the Scottish is, I believe, most common; though, from its resemblance to the calcareous, it has probably been often overlooked. The three last have very rarely, and the Sydneian indeed has only once, been met with.

White is the natural colour of all earths: the other colours which are found in them, proceed from inflammable or metallic substances.

Of Calcareous Earth.

Calcareous earth, in its commonest state, is called *limestone*, or *spar;* but in this state it is combined with a peculiar acid, expellible by heat, and by most other acids in an aërial form, and hence called *aërial acid*, or fixed air, from its having existed in a fixed state before its expulsion. When this acid is expelled, the earth, uncombined with any other substance, is then called *lime,* or *common* or *calcareous lime,* to distinguish it from other earths, which also form limes when free from all combinations, viz. the Barytic and Scottish earths.

Lime, simply so called, or calcareous or common lime, when unmixed with any other substance, is perfectly white, and, if in lumps, moderately hard and brittle, its specific gravity 2,3.

It has a hot burning taste, corrodes animal, and even vegetable substances, in some degree.

When in lumps, it heats and bursts by the affusion of water.

In the temperature of 60° it requires between 6 and 700 times its weight of water to dissolve it, but in a boiling heat about one-half less; but most of this excess falls as the water cools, so that the strongest lime-water contains no more than about one grain per ounce troy: it never crystallizes while pure.

It is combinable with all acids, particularly with the nitrous and marine: 100 parts standard nitrous acid take up, when saturated, in the temperature of 60°, 38,68 of lime: and 100 parts lime require for their solution 258,5 of standard nitrous acid; 100 parts standard marine acid are saturated by 95,49 of lime; and 100 parts lime require for their solution 104,72 of standard marine acid in the temperature of 60°.

These solutions are with difficulty brought to crystallize; the vitriolic acid snatches the lime from both of them, and with it forms selenite or gypsum; which, if the solution be saturated, and not very dilute, precipitates, or may be made to do so, by evaporation, or the addition of spirit of wine.

Nitrous selenite, heated to redness, easily parts with its acid, particularly in open vessels; but marine selenite obstinately retains it in the same circumstances. Both selenites have a bitter taste.

Pure lime, except placed on clay, is infusible not only by the greatest heat of our furnaces, but also by that of the focus of a burning glass, or the still greater given out by the action of pure air on burning charcoal, as Mr. Lavoisier has shewn.

There are three fluxes usually applied to procure the fusion of earths, namely, fixed alkalis (generally the marine), borax, and microcosmic salt; of these borax is most appropriated to calcareous earth, and next to borax, microcosmic salt; they fuse lime without effervescence; and mild calx (so I call lime united with fixed air) with some effervescence; but alkalis barely divide and disperse it.

According to Mr. Lavoisier, 1000 parts lime are capable of absorbing (when fixed air is not admitted), and of retaining, in a heat of 600° Fahr. 228 parts of water, that is, between one-fourth and one-third of its weight; and mild calcareous earth, such as powdered chalk in its usual state of dryness, can absorb about one-half of its weight of water, without letting any drop out of it; but if exposed to the open air, it will soon dry, and give it out.

Barytic, or Ponderous Earth.

This earth, when free from all combination, (a state in which nature never presents it), forms also a lime with many of the properties of common lime, but differs from it by many others. It is soluble in water; but, in the temperature of 60°, it requires, according to Bergman, 900 times its weight of that solvent to hold it in solution.

This lime is soluble in the nitrous and marine acids, though much more difficultly than common lime; but with these acids it crystallizes, and the crystals are not deliquescent as those afforded by common lime are.

These solutions are precipitated by the vitriolic acid as those of common lime; but the selenite, of which common lime is the basis, is soluble in about 450 or 500 times its weight of water; whereas that which has barytic lime for its basis is insoluble in less than 40,000 times its weight of water.

If barytic lime-water be added to a solution of tartar vitriolate, or Glauber's salt, it seizes the acid of these salts, and forms a precipitate; it also precipitates the solutions of nitrated and muriated stronthian.

The usual fluxes affect it as they do calcareous earth.

Magnesia, or Muriatic Earth.

Various clays, stones, and salts, particularly Epsom salt, contain this earth; but uncombined, or combined simply with fixed air unmixed, it scarcely ever occurs; when pure, it is perfectly white: its specific gravity is about 2,3.

It requires about 7900 times its weight of water, to dissolve it in the temperature of 60°.

It is combinable with all acids; with the nitrous and marine it forms salts that difficultly crystallize, and are deliquescent. If to a saturate solution of these salts the vitriolic acid be added, though it takes the magnesia from the above-named acids, yet it forms no precipitate, as it does when it seizes the calcareous, barytic, or Scottish earths, in the same circumstances. The salt, formed of the vitriolic acid, and magnesia, is also very soluble in water; whereas the salts, formed of this acid and the preceding earths, are very difficultly soluble; the former is bitter, the latter are insipid, or nearly so.

Magnesia, in its pure state, is not as easily dissolved as when combined with fixed air; 100 parts of it require for their solution 194 of the vitriolic standard acid, 286 of the nitrous, and 215,8 of the marine.

And 100 parts of the vitriolic standard acid take up 51,54 of pure magnesia; 100 parts of the nitrous acid 34,96; and 100 parts of the marine 46,34.

This earth, exposed to the strongest heat, will neither burn to lime nor melt: it is fused by the same fluxes as lime and mild calx, and with the same appearances.

In its usual state of dryness mild magnesia is capable of taking up $1\frac{1}{10}$ times its weight of water without letting out any drop; but, if exposed to the open air, it suffers it to evaporate, though more slowly than calcareous earth does.

Earth of Alum, or Argill.

This earth forms the basis of common alum, and hence is by many called aluminous earth; it is also the true clayey part of common clay; and hence, to distinguish it from the other heterogeneous parts, it is called argill.

It is seldom found nearly pure, and never absolutely so; the purest is extricated from alum by precipitation with the caustic volatile alkali; it is very white, smooth, and unctuous; its specific gravity, when thoroughly dry, and free from fixed air, is 2,00; it is very diffusible, but not more soluble in water than pure magnesia.

It is combinable with most acids, but (except in the act of precipitation) with great difficulty; with the vitriolic it forms alum; with the nitrous and muriatic it difficultly crystallizes.

When heated it hardens and diminishes in bulk, but it is infusible in the strongest heat of our furnaces: the heat, however, given out by pure air appears to affect it, and dispose it to fusion, more than it does any of the before-mentioned earths.

Microcosmic salt seems the flux best suited to argill; it dissolves it with considerable effervescence. Borax is nearly as powerful, and produces less effervescence; but alkalis act nearly as on the preceding earths.

Even in the moist way, caustic alkalis are capable of acting on argill.

In its usual state of dryness it is capable of absorbing 2½ times its weight of water without suffering any to drop out, and retains it, when exposed to the open air, more obstinately than the foregoing earths: however, in a freezing cold, clay contracts more than any other earth, and, in contracting, squeezes out its water, and thus parts with more of it in that circumstance than other earths do; a fact of some importance in agriculture, as well as mineralogy.

Siliceous Earth.

This earth is generally found in a stony state, it abounds in flint, and is thence called *siliceous*; but it is still purer in mountain crystal, and in quartz: the purest is perfectly white or colourless; its specific gravity is 2,66.

In its usual state of concretion it appears insoluble in water; but, in that state of division in which it exists, when precipitated from its solution in fixed alkalis, it is perfectly soluble in 1000 parts of water.

In general it combines with no acid, except that extracted from the stones called fluors, a variety of which is generally known under the appellation of Derbyshire spar; but, in the moment of precipitation from its solution in fixed alkalis, many eminent chemists think it capable of uniting with most acids*; at least, it is certain that an alkaline solution of silex, much diluted with water, may be saturated and super-saturated with an acid without any precipitation; and this is one of the surest characters of this earth.

By the experiments of Mr. Lavoisier, it appears that the strongest heat that can be applied, namely, that excited by pure air, is incapable of melting it. The slight degree of emollescence that some others have observed, most probably proceeds from some slight mixture with some other earth.

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* Mr. Dolomieu, 40 Roz. 379, thinks it is in its usual state united to inflammable air, but freed from that air when united to alkalis, and in that case combinable with acids, in separating from which it again retakes this air from water.

Fixed alkalis, whether vegetable or mineral, are the true solvents of siliceous earth in the dry way: one part mineral alkali will flux two of siliceous earth with effervescence. Borax also fuses them, but much more slowly, and without effervescence. Microcosmic salt is still less effectual.

Caustic fixed alkalis attack siliceous earths also in the moist way, when very minutely divided, and take up nearly one-sixth of their weight.

Siliceous sand is capable of absorbing about one-fourth of its weight of water without letting any drop from it; but, on exposure to the open air, it suffers it to evaporate much more readily than any of the foregoing earths do in the same circumstances.

Of the characterizing Power of the foregoing Earths.

Having set forth the distinctive characters of the foregoing earths, singly taken, we are now to remark the different powers they possess, of impressing or communicating their respective characters, when mixed or combined with each other, to the compound of which they form a part.

1. Calcareous earths feel dry, meagre, and harsh, when *in a loose or semi-indurated state;* and this property they communicate to other earths *in the same state,* when they constitute

at least 40 or 50 *per cent.* of the whole. When in a stony state they are never hard enough to strike fire with steel; and they impress this property on compounds in a stony state, in which they enter in the proportion of 30 *per cent.*

9. Barytic earth, when not the principal ingredient in a compound, has scarcely occurred in any considerable proportion. Its high specific gravity it undoubtedly communicates, but the porous structure of the compound may be such as to conceal it.

3. Magnesia feels smooth; in a stony state it never occurs single, but it impresses a character of smoothness and unctuosity on all compounds in which it has not the opposite characters of calcareous earth to encounter, and into which it enters in the proportion of 18 to 20 *per cent.* It also gives a greenish cast to stones, and a bias towards a fibrous, striated, or slaty structure, and some lustre, particularly of the silky kind.

4. Argill is also soft, smooth, and unctuous to the feel; it strongly absorbs water, and hardens when heated. In loose or semi-indurated mixtures, it imparts these properties to calcareous earths only when it exceeds them in quantity. With magnesia it can have no struggle; but, on siliceous earths, it impresses its characters in some degree, even when it amounts to 13 or 14 *per cent.* of the whole. In stony compounds, if it exceeds 20 *per cent.* and is mixed with magnesia, it gives a bias to a slaty or lamella structure. In the proportion of 20 or 30 *per cent.* it generally diminishes, and when in a greater proportion, extinguishes the character of siliceous earth: to this observation there are very few exceptions.

5. Siliceous earths, in a stony or sandy form,

are remarkable for their hardness, transparency, and lustre; but their power of communicating these properties is inferior to the powers of communication possessed by the foregoing earths. When silex is exceedingly comminuted, as it is after the precipitation from alkalis, it is light and spungy.

Scottish, or Stronthian Earth.

This is a new earth, first noticed as such, as far as I can find, by Dr. Crawford, who sent me a specimen of it in the year 1790. I have since subjected it to various experiments lately read to the Royal Irish Academy, an account of which may be found in their Transactions; from this paper I select the following particulars:

1. It has hitherto been found only in a mild state, united to fixed air: of this species I shall hereafter give a description.

2. Like common limestone, it loses its air in a strong heat, and then forms a lime.

3. This lime is much more soluble in common water than that afforded by common limestones, and is also specifically heavier.

4. This lime, like the barytic, decomposes tartar vitriolate: but the selenite it forms is itself decomposed by barytic lime.

5. It decomposes the solutions of common gypsum, and of nitrated or muriated calx.

6. Vitriolic acid dropped into this lime-water immediately forms a visible precipitate, which it does not in common lime-water.

7. This lime-water has also the singular property of affording, when saturated, compressed rhomboidal crystals, which are nothing else but pure lime.

8. Its solution, in the nitrous or marine acids, may be rendered so saturate as not to discolour litmus; whereas the solutions of barytes in those acids have always an excess of acid.

*Jargonic Earth**, *or Jargonia.*

This earth hath been discovered by Mr. Klaproth; it has as yet been found only in the stone called *Jargon,* or *Circon,* of Ceylon, of which more hereafter.

This earth resembles argill more than any other earth, though it differs essentially from it in some respects. Its colour is white, and its specific gravity probably exceeds 4,000.

1. It is incapable of uniting to fixed air; at least, when precipitated from acids by mild alkalis, it takes up none.

2. It is soluble in dilute vitriolic acid (as also in the nitrous and marine); and with a slight excess of this acid it forms, in a moderate heat, by spontaneous evaporation, stelliform crystals of an astringent taste, easily soluble in water. Its solutions, like those of argill, are precipitable by caustic volatile alkali, as well as by the fixed.

3. It is also soluble in the concentrated acetous acid; this solution will not crystallize; but, if it be evaporated to dryness, the saline powder thus had will not attract the moisture of the air, as acetous alum does; neither does the acetous acid act so powerfully on argill as on this earth.

4. It is insoluble in a boiling solution of caustic fixed alkali, in which argill is perfectly soluble.

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* 3 Berl. Beobacht. 147.

5. It is infusible, not only by fixed alkalis, but also by microcosmic salt, to which argill yields. Borax however melts it, but without any effervescence, in which respect also it differs from argill.

Hence it is plain Mr. Klaproth is justified in reckoning this a new earth, of which it were wished we were acquainted with many more of the properties.

Sydneia, or Sidney Earth[*].

For the discovery of this singular substance, we are indebted to that celebrated philosophic artist, Mr. Wedgewood.

This earth is contained in a compound mineral imported from Sidney Cove, in South Wales, consisting of fine white sand, some colourless mica, a few black particles resembling black lead, and a white earth which appears to be argillaceous, with which the new earth appears to be mixed, and from which it is extracted by the marine acid. It was found to possess the following properties: its colour is white.

1. It is fusible in a heat of 150 of Wedgewood, which no other simple earth is.

2. It is soluble immediately and directly in no other acid but the marine, at least not in the nitrous or vitriolic.

3. The marine acid, to dissolve it, must not only be in large proportion, and concentrated, but also heated above 140° Fahr.

4. From this solution this earth is not precipitable by the Prussian alkali; but it is by common alkalis, which instantly render its solution milky.

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[*] Phil. Trans. 1790, 306.

This solution is also precipitable by affusion of pure water in the smallest quantity if saturate; but, if unsaturated, it may bear a considerable addition of that fluid without precipitation.

The addition of spirit of nitre to a saturate solution occasions no precipitation; and, if the quantity of nitrous acid added exceeds, or equals, that of the saturate solution, it will protect it from precipitation by water.

Neither does the addition of the concentrated vitriolic acid precipitate the saturated solution, but it has a stronger affinity to this earth than the marine has; for if the quantity of vitriolic acid added be nearly equal to that of the solution, heat and effervescence will arise, the liquor will become turbid, and the marine acid will be expelled in white fumes: the mixture then heated to boiling becomes transparent, and continues so; this vitriolic solution is also precipitable by water like the marine.

5. The marine solution does not crystallize, but becomes butyraceous and deliquescent. The butyraceous mass is pale yellow, and not corrosive; it parts with its acid in a strong heat.

Adamantine Earth.

Of this substance, which was lately discovered by that excellent analyst, Mr. Klaproth, in a stone called *adamantine*, or *diamond spar*, very little is as yet known. In decomposing this spar he found an earth which constituted about one-fourth of its weight, which was insoluble in acids, and infusible by alkalis; by this last property it differs from siliceous, and by the former from all other earths; he does not however positively assert that it is not some unknown compound of other earths. 2 Berl. Beobacht. 297 *. Its existence is also suspected in some other stones, as will be seen in the sequel. Its specific gravity probably exceeds 3,000.

Calces of Iron.

To these simple earths we must also annex the consideration of calces of iron, as they almost always accompany earthy or stony substances, are mixed or combined with them, and are the source of many both of their external appearances and internal properties.

Calces of iron are formed of iron combined with different proportions of pure air, and frequently of water also, and fixed air.

One hundred parts metallic iron are capable of taking up 66 or 70 of pure air. When 100 parts iron contain but 40 of this air, the compound is still magnetic.

CHAP. II.

OF THE FORMATION OF STONY SUBSTANCES.

THE slighest acquaintance with the stony substances that come under our inspection, is sufficient to convince us they were once in a soft or liquid state. Many of them have the appearance of having been crystallized, like salts, in separating from their solvent whatever that may have been; and these crystals discover all the variations to which saline crystals are liable. Many of them inclose organized substances which they could not have admitted but when in a soft or liquid state; many of them appear to have been formed round mineral substances, as these, having received their shape and form from the operations of art, could never have introduced themselves into them. The bare mention of these circumstances is sufficient, as this point has, I believe, never been disputed. The only difficulty that at present occurs is, to ascertain the nature of that fluid which was capable of holding in solution or suspension that immense mass of solid substances of which the globe of the earth consists. On this head I shall only remark, that with regard to stony substances that are placed deeper than one mile beneath the level of the sea, we have no reason to affirm they were ever in a soft state, as we are perfectly unacquainted with them; and, with respect to those that are nearer to, or on the surface of, the earth, we may, for the present, suppose that fluid to have been in most cases mere water, in some circumstances aided by saline substances, and, in comparatively much fewer cases, aided by volcanic fires. The probability, that fire has been the universal agent of this solution, we shall afterwards examine in a distinct dissertation.

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* Mr. De la Metherie, in the 2d vol. of his new edition of Mongez's *Manuel de Minéralogiste,* says, Mr. Klaproth found this earth soluble in the vitriolic and acetous acids; but this is plainly an oversight.

Supposing then the simple earths, and ferruginous and bituminous substances, already mentioned, reduced to that degree of division which solution requires, to exist in that mass of waters which now constitutes our oceans, seas, lakes, and rivers, this mass, considerable as we see it, is nevertheless evidently insufficient to hold them in solution: they will therefore soon unite, and those soonest which have most affinity to each other, and least to the fluid in which they are suspended. Hence some will be crystallized, and some will be formed by simple deposition, as we see clay deposited by water.

Hence stony substances, formed in the aqueous fluid, owe their origin some to crystallization, some to deposition, and some partly to the one partly to the other.

Crystallization is that operation by which solids dissolved, or finely diffused in a fluid, coalesce by virtue of their mutual attraction, into masses of a determinate and angular shape: if this operation be accomplished in the most perfect and regular manner, the shape of the crystal will be determined by that of the first molecule formed, the subsequent additions being made to certain surfaces according to certain laws; but, if the operation be disturbed by any impediment, certain surfaces will receive greater additions than others are allowed to receive, and in that case either no determinate angular shape will ensue, or a shape very different from what nature seemed principally to have had in view will arise.

Hence this operation is susceptible of various stages and degrees of perfection.

As the additions made to crystallized surfaces are gradual and uniform, these surfaces have generally a smooth and polished appearance; however, the mixture of foreign substances, that are capable of impeding the operation,

ration, diminish this lustre in proportion to their influence.

Crystallized substances are also very frequently transparent; and these that are naturally so would always be so, were they not disturbed in the course of the operation; but some are naturally opaque.

The greatest impediment to crystallization, is want of liberty of the dissolved particles to arrange themselves according to the laws of the attraction of the different surfaces; this restraint may arise either from agitation, which disturbs the direction of their spontaneous attraction, or from their being forced into contact with each other in a fluid in which they are too much crowded, or by the introduction of foreign substances, which prevent their mutual contact.

Some substances are more apt to be disturbed by the introduction of foreign substances than others; thus we see calcareous spars crystallized in a regular form, though mixed with a considerable proportion of silex, in the calcareous sand-stones of Fontainbleau.

The first step in the process of civilization is the formation of grains; the second is the increase in one dimension; the third in two dimensions, and the fourth in three dimensions; the grains themselves however, to be visible, must receive accretions in the three dimensions. If the process be uninterrupted, no traces of distinction will be perceived, and the whole will appear perfectly uniform; but, if it be disturbed in the first step, no crystallization can take place: if in the second, the grains will appear distinct, small or gross, coarse or fine, according to the nature of the disturbance, whether by the interruption of the process, or the accession of foreign matter; this latter generally produces coarse or rude grains in proportion to the quantity.

If the disturbance only takes place in the third stage, we shall have fibres or striæ, as complete surfaces cannot be formed; the striæ, having more extension in breadth than the fibres or filaments, argue a smaller degree of disturbance than the mere fibrous appearance.

If during the third stage, the striæ be forced into contact, by the gradual dereliction of the fluid that kept them suspended, they will form lamellæ in proportion as they are deserted, which will either adhere to each other, and then fall confusedly, being too heavy to be supported by the menstruum, or, if supported, will be superimposed on each other.

But if the process of crystallization be disturbed only in the fourth stage, then the form and shape only of the crystals will be more or less altered.

All these steps are noticed and described by chemical writers; and particularly by the celebrated Rouelle, in the Memoirs of the Academy of Paris, on the crystallization of salts.

Deposition is an effect that takes place when solids have little or no tendency to crystallize, are divided ever so minutely, and suspended in a fluid specifically lighter, and to which they have no affinity, or which is not sufficiently abundant to hold them in solution; it takes place so much more slowly, as the particles suspended approach more to the specific gravity of the fluid, or are more minutely divided.

Deposition is either simultaneous or periodical; in the former case vast unwieldy stony masses have been produced, in the latter slaty masses.

The fluid from which stony substances have been deposited appears to have contained a mixture of bitumen, and most probably also of carbonaceous substances; and hence some proportion of these is often found in stones formed by subsidence.

In general, deposition must be a later operation than crystallization; but it must frequently have happened that both should take place at the same time, from an unequal mixture of substances, susceptible some of the one, and some of the other; and hence many stony masses owe their origin partly to the one, and partly to the other.

CHAP. III.

OF THE DISTINCTIVE CHARACTERS, AND SYSTEMATIC ARRANGEMENT, OF EARTHS AND STONES.

The object of mineralogy, at least in the sense in which that word is taken in this work, being to point out the method of distinguishing the various substances of which it treats, it is necessary at the outset to give a general idea of the means it employs, to prove their sufficiency, and remove every ambiguity and obscurity that may attend their application. On the most general view of the subject, it is plain these means can be no other than the properties of the substances themselves, or at least such of them as are most obvious, of most easy application, and at the same time characteristic of the substances to which they belong; we must therefore examine what those properties are.

The properties of substances, as far as we can understand them, are the relations which they bear to our senses, and to other substances on or from which they are capable of producing or receiving some peculiar observable change. These last-named substances are called *chemical agents;* the properties which relate to our senses are called the *external,* and those that relate to chemical agents the *internal,* characters of bodies.

In the Treatise I formerly compiled on this subject, I considered the *internal* properties of minerals as the only that were sufficiently characteristic of the substances to which they belonged. A more mature consideration has undeceived me. I perceived that names having been given to different mineral substances, sometimes by reason of their external properties, sometimes by reason of their internal, and the business of the mineralogist being to distinguish the subjects to which those different names have been given, from each other, he must in some cases rely chiefly on the external, and in others chiefly on the internal, characters; but, if any ambiguity remain, the decision must rest with these.

Thus diamonds, rubies, emeralds, and other precious stones, received their names, and were well distinguished from each other, long before their *internal* properties were known, if even at present they can be said to be so: there must surely then be some means of distinguishing them, and these means can be no other than their external properties: it were indeed a melancholy circumstance to a jeweller, if there were no other certain way of distinguishing diamonds than their internal properties; for, the only one of that kind with which we are at present acquainted, is their destructibility by heat: he should therefore destroy the stone before he could know it.

What I have said of precious stones, may be understood of far the greater number of stony substances; either they have not been analyzed, or the analyses given of them present different results, and consequently are undecisive: yet, since they *can* be distinguished, it is plain this distinction *may* be made by external characters.

It must be remarked, however, that, in distinguishing earths and stones which have never been analyzed, or which, independently of any analysis, have received their denomination from *mere external* characters, ambiguities frequently arise; and doubts may remain, which can be removed only by the application of chemical tests or internal characters, not indeed analyses, but other tests of more easy and speedy application.

Again, many minerals have received their denominations merely from internal properties, such as limestones and marls, &c. The only certain tests of these are chemical agents, though external characters may afford a high degree of probability.

The over-zealous disciples of Mr. Werner contend for the sufficiency of external characters, in all cases, with respect to stones that have been already analyzed. It were an easy, if not an invidious, task to refute them, from the mistakes into which the most eminent of them have fallen, through too great reliance on these characters; but, in justice to Mr. Werner, I must say, that he recommends the aid of easy chemical tests, and has in some cases happily applied them.

It has been objected to external characters, by myself and many others, that they are not of a fixed and permanent nature, nor appropriated purely and singly to any particular species, but common to many, and incapable at least as to their gradations, of a definition sufficiently precise. The first part of this objection is certainly true, if applied only to one or two of those characters; but, if they be taken in their totality, it will very rarely happen that they suit any mineral but one, and in such cases chemical tests may decide; yet even this assistance may be sometimes unsuccessful, as in nature many species border upon, and pass into, each other, and thus deny sufficient grounds of distinction. As to the difficulty arising from the vague definitions of those characters, this has been in great measure removed by Mr. Werner, and I have endeavoured to render them still more precise.

The necessity of applying these characters, and employing them in that strict and determinate sense which Mr. Werner has affixed to them, must be obvious to every reader of mineralogical writings. Who does not lament in seeing most of these (those only of the Wernerian school excepted) rendered useless by the defective and imperfect descriptions of the minerals of which they treat? Through the neglect of adequate descriptions, the same name has been imperceptibly applied to minerals widely different from each other; and, conversely, minerals of the same species have been distinguished by different appellations.

I now proceed to a brief enumeration and explication of the external characters given by Mr. Werner *, or at least of such of them as I think necessary, with the few improvements I think I have made in their descriptions: these consist in denoting the degrees of intensity of some particular qualities by figures.

External Characters.

These are, *colour, shape, lustre, transparency, texture, cohesion, density, adhesion* to the tongue or fingers and general *feel, colour of a streak, absorption* or *diffusion* in water, *smell,* and *taste;* to which Mr. Werner adds the various *refrigerating* powers of bodies, but these I mostly omit as too vague.

Internal Characters.

Relation to acids, changes operated in low heats; fusibility and other changes in higher degrees of heat, phosphorescence, magnetism, electricity, and, lastly, the results of a just analysis.

Colours.

Of these I shall name only the most simple, and those whose denominations require some explanation.

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* There are terms of which I could never learn the precise meaning, particularly the word *Derbe.*

White.—Milk white—contains a slight mixture of blue.

Grey—a mixture of white and black, in which however the white predominates.

Lead grey—grey with a slight mixture of azure blue.

Pearl grey—pale grey with a slight mixture of violet blue.

Smoke grey—dark grey with a slight mixture of blue and brown, as in flints.

Steel grey—nearly the same, but with a more metallic aspect.

Black.

Blue.—Indigo blue—the deepest, nearly black.

Azure blue—somewhat lighter.

Smalt blue—paler than the foregoing.

Lavender blue—blue with a mixture of grey, and a shade of red.

Violet blue—reddish blue.

Celestial blue—pale blue with a slight shade of green.

Green—results from a mixture of yellow and blue.

Verdigris green—that in which no shade of yellow is perceptible, rather bluish.

Celadon green—bluish green with a shade of grey.

Mountain green—pale greyish green.

Emerald green—pure green.

Meadow green—lively green, in which however the yellow predominates.

Apple green—green verging to white.

Leek green—dark green with a mixture of brown.

Pistachio green—meadow green with a mixture of brown.

Sparrow grass green—pale yellowish green with a mixture of grey and brown.

Olive green—pale yellowish green with a strong mixture of brown.

Canary green—pale yellowish green without any mixture of brown.

Yellow—results from a mixture of orange and green.

Sulphur yellow—pale greenish yellow.

Lemon or gold yellow—the purest.

Honey yellow—yellow with a mixture of reddish brown.

Wax yellow—darker than the foregoing.

Copper yellow—pale metallic with a shade of red.

Brass yellow—pale metallic with a shade of green.

Straw yellow—well known.

Wine yellow—pale reddish, and somewhat brownish.

Ochre yellow—somewhat dark with a shade of brown.

Isabella yellow—brownish yellow with a shade of brownish red.

Orange yellow—reddish yellow.

Red.—Aurora red—high red with a shade of yellow.

Hyacinth red—high red with a shade of brown.

Brick red—well known.

Scarlet red—well known.

Copper red—metallic with a shade of yellow.

Carmine red—the purest.

Blood red—darker, well known.

Cochineal red—high red with a mixture of bluish grey.

Crimson—high red with a shade of blue.

Flesh red—pale red of the crimson kind.

Rose red—pale red of the cochineal kind.

Peach flower red—pale whitish red.

Mordoré—dark red of the crimson kind, mixed with brown.

Brownish red—blood red mixed with brown.

Brown—results from a mixture of red, black, and yellow.

Reddish brown—brown verging to blood-red.

Clove brown—dark brown with a scarcely perceptible shade of crimson.

Yellowish brown—pale brown with a shade of ochre yellow.

Tombac brown—metallic yellowish brown.

Liver brown—greyish brown.

In examining the colours of fossils the internal is chiefly to be regarded, as the external is often stained or tarnished, and the surface frequently of a different nature from decomposition or mixture with a foreign mineral.

Shape.

The shape of fossils is either *indeterminate, particular,* or *regular.*

Indeterminate, or *amorphous,* is that which can be compared with no other.

Particular Shapes.

Dentiform, short, somewhat crooked, cones.

Filiform.

Capillary still finer.

Interwoven, or *reticular.*

Dendritic, or *arborescent.*

Coralliform, or forked and crooked [*].

Stalactitic, cones issuing from a common stem.

Tubuliform, slender cylinders adjoining each other.

Ramified.

Botryoidal, like grapes.

Kidneyform, or *reniform*, round elevations bearing other small elevations.

Bulbous, presenting rounded elevations with some depressions.

Depressed, an elevation beat in in the middle [†].

Specular, presenting a flat polished surface like a mirror.

Cellular, presenting cells formed of laminæ crossing each other.

Perforated, traversed with round holes.

Corroded.

Determinate.

Under this head are comprehended the various forms of crystallized substances, resulting from the assemblage of a determinate number of sides

The varieties of form which crystallized bodies present I shall not attempt to enumerate, and so much the less, as I think their detail of very little use. Those who wish for more information on this head, may consult Romé de Lisle, Mr. Werner, and an excellent Dissertation by Mr. Wideman, in the 4th volume of the Berlin Observations.

A surface on which very minute crystals abound, is called *drusy*.

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[*] Zakig.

[†] Gestossen.

Lustre.

Lustre is the gloss, and often brightness, which fossils discover, sometimes on their external surface, but more frequently on their internal surface, when fresh or broken. Of this lustre Mr. Werner distinguishes various sorts; the *metallic*, the *pearly*, the *waxy*, that of *grease*, the *glassy*, and the *common*. When no particular sort is mentioned, it is understood to be of the common kind.

There are also different *degrees* of lustre, which I denote by figures.

1. denotes the strongest, and is perceived at a certain distance, such as that of diamonds and polished metals.

3. denotes a weaker, such as that of crystals or metals not much polished *.

2. denotes a still weaker, as that of silk, or still less glossy †.

1. when only a few particles reflect any lustre, or it is exceeding weak.

2. dull, reflecting no lustre at all.

When lustre is mentioned simply, without specifying which, the *internal* is understood.

Transparency.

Of this Mr. Werner distinguishes several *degrees*, which I note by figures.

4. denotes that degree which allows objects to be clearly distinguished ‡.

3. that which suffers objects to be perceived, but not distinctly §.

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* Sehr glanzende of Werner, and glanzende.

† Wenig glanzende.

‡ Durchsigtig.

§ Halb durchsigtig.

2. that which transmits light, but does not permit objects to be discerned *.

1. that which transmits light only at the edges.

0. denote perfect opacity.

When a fossil possesses these qualities in various degrees, I place the figure denoting the most usual degree first, and the least common degrees follow in their order.

Texture, or Fracture.

The texture of a fossil is discovered by breaking it; and hence Mr. Werner commonly calls it the *fracture;* though this appellation be not the most just, yet, as it is now in constant use, and well understood, I shall also employ it in the same sense. Mr. Werner no where mentions in what direction this fracture should be made; but I think it may be collected that it should be made in the direction in which it may most easily be effected, and most commonly the cross fracture is to be understood: the natural seams or joints of the stone are to be avoided.

The form of the internal surface of a fossil, which its fracture presents to us, results from that of the minute particles that compose it, and are called the *grain* of the stone or fossil; these may be so minute and close as scarcely to be distinguished, or more open and distinct: according to the direction and mode of union of these particles the fracture is distinguished into *compact, fibrous, striated, foliated,* and *slaty.*

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* Durch scheinend.

*Of the Compact Fracture**.

The compact fracture is that in which the minute particles of a fossil are either uniformly arranged, or at least have no particular determinate direction nor inequalities, but those arising from the mere act of breaking it: of this fracture there are six sorts, the *uneven, even, conchoidal, splintery, earthy,* and *hackly*.

The *uneven* takes place when great inequalities prevail in the direction of the line of fracture.

The *even* is that which presents flat surfaces with scarcely any prominent parts.

The *conchoidal,* otherwise called *testaceous,* presents round elevations and depressions like shells . the *perfect* is single, and the elevations are often wrinkled; the *imperfect* is flatter, or the elevations and depressions are more minute and more numerous.

The *splintery* discovers scales arising from splits or fissures parallel to the line of fracture, which are thicker at the end at which they still adhere than at the end at which they are separate; and consequently are opaque at the thick, but somewhat transparent at the other end, else their separation would scarcely be perceived: these splinters are either *coarse* or *fine,* sometimes so minute as to be scarcely discernible. From the size of these splinters, minerals are denominated coarse or fine grained.

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* Much obscurity prevails in this part of Mr. Werner's treatise, which he has of late I understand much improved; and hence I may have mistaken his meaning in some instances, more especially as I cannot procure the original (which I lost), and am obliged to use the French translation. I also add somewhat from Mr. Karsten.

The *earthy fracture* is that which presents small rough prominences, as dry clay: it is however distinguished into *coarse* and *fine*. It is commonly destitute of lustre and transparency.

The *hackly* presents sharp points, easily perceived in feeling it.

Of the Fibrous Fracture.

This presents either lines or threads, some so fine as to be scarcely perceptible, and some grosser or coarser. These are *straight* or *curved, parallel* or *diverging,* or *stellated,* that is, diverging like the rays of a star from one common center, or *bundled* together, or *interlaced.*

Of the Striated Fracture.

The striated fracture consists of long narrow separable parts, laid *on* or *beside* each other; they have proportionably more length than breadth, and are thicker at one end than at the other; however they frequently differ in breadth, and hence they are divided into *fine,* or *narrow,* or *broad.* Their direction is also either *straight* or *curved, parallel* or *diverging,* or *stellated,* or *bundled,* or *interlaced.*

Of the Foliated Fracture.

This discovers plates nearly as broad as long, with polished shining surfaces, and commonly even specular; some have large, some exceeding minute *facettes,* some *straight,* some *curved,* some *undulating* or *wavy,* some *parallel,* some *diverging:* when small and irregularly placed, they are often called scales. Minerals that consist of grains, and are at the same time foliated, are called *granularly foliated*. When the lamellæ abound in cracks, I call that fracture the *shattered foliated*.

Of the Slaty Fracture.

This Mr. Werner has not explained. It seems to differ from the foliated in this, that the laminæ are larger, thicker, and have not a polished, or at least not a specular, surface.

The imperfectly slaty is often called *shistose*.

We may also distinguish the *thick, thin* or fine slaty, and also the *curved* and undulating.

Shape and Sharpness of the Fragments.

When a fossil is broken into fragments, the shape of these is most frequently *indeterminate*, but sometimes *cubical, rhomboidal*, or *pyramidal*, or *trapezoidal*, although these forms are often disguised: also the *long splintery*, the *broad splintery*, and the *tabular* which consists of plates that grow thinner and sharp at the extremities, are observable.

When, in the sequel, the form of the fragments is not mentioned, it is to be understood that it is *indeterminate*.

The sharpness of the fragments must also be noticed; 4, denotes the sharpest, as those of glass; 3, sharp, but in a lesser degree; 2, rather sharp; 1, rather blunt; 0, perfectly blunt.

Distinct Concretions.

These are discovered by their distinct and separate position in the internal structure of a mineral, or by the intervention of a delicate rift or fissure; they are of three sorts, the *granular*, *lamellar*, and *columnar*.

The granular have nearly an equal breadth and thickness, and appear rather rounded; they are either *gross*, *coarse*, *small*, *fine*, *angular*, &c.

The lamellar are those whose length and breadth are considerable in respect to their thickness; they are *thick* or *thin*, spherically convex, &c.

The columnar are those whose length much exceeds their breadth and thickness, which are nearly equal.

Cohesion.

Under this head, the firmness, hardness, and impenetrability of minerals are noted: those that strongly resist fracture are *firm*; those that a blow shivers into many pieces are called *brittle*.

Of hardness Mr. Werner distinguishes many degrees: 1° he calls those minerals *hard* that give fire with steel, and among these he distinguishes those that *yield to the file*, as the white copper ore, hæmatites, &c.; those that yield but slightly, as flints, crystal, calcedony, &c.; those that *do not yield at all*, as diamonds, rubies, emeralds.

2° he denominates those *half hard* that do not give fire with steel, and are difficultly scraped by a knife, as fluors, zeolytes, calcareous spars, basalts, &c.

3° he calls *tender* or soft, those that may easily be scraped by a knife, but not by the nail, as baroselenite, mica, serpentines, &c.

4° he calls *very soft or tender*, those that may be scraped by the nail, as steatites, gypsum, talc, &c.

I distinguish the various degrees of hardness by figures.

3. denotes the hardness of chalk.

4. a superior hardness, but yet what yields to the nail.

5. that which will not yield to the nail, but easily and without grittiness to the knife.

6. that which yields more difficultly to the knife.

7. that which scarcely yields to the knife.

8. that which cannot be scraped by a knife, but does not give fire with steel.

9. that which gives a few feeble sparks with steel, as basalt.

10. that which gives plentiful lively sparks, as flint.

The superior degrees are discovered by observing the order in which stones cut each other. Under this head also, *flexibility* and *elasticity* may be noticed.

Density.

This is found by taking the specific gravity of stones, &c. in distilled water at the temperature of from 59° to 64° Fahr.

As the temperature of 62°, the true temperature for taking specific gravities, does not always prevail, the specific gravity of a solid being found at any other temperature between 45° and 75° Fahr. may be found by the following table, such as it would be if examined when both it and the water were at 62°.

Then

Temperature.	Specific gravity of Water.
45	10008
50	10007
53,6	10005
55	10004
57	10003
59	10002
60,5	10001
62	10000
64	9998
66	9997
68	9995
69	9994
70	9993
71	9992
72	9991
73	9989
74	9988
75	9987

Then as the specific gravity of water at 62° is to its specific gravity at *n* degrees between 45° and 75° inclusively ::, so is the specific gravity of any solid *found at n* degrees to that which it would be found to possess at 62°.

Again, as distilled water cannot always be procured, it is proper to know what the specific gravity found in common or pump water would amount to, if instead of pump water distilled water had been used. This may be discovered in the following manner: supposing you have some particular solid, whose loss of weight in distilled water of the temperature of 62° is known, but if the temperature 62° does not then prevail, first find what the loss of weight of the solid would be in distilled water of the given temperature by the annexed table, and this analogy.

As the specific gravity of distilled water at 62° is to its specific gravity at *n* degrees, so is the loss which a solid suffers in it at 62° to the loss which it suffers in it at *n* degrees. By this means you find the loss that particular solid would suffer at *n* degrees, the given temperature, in distilled water; this solid therefore should make a part of the mineralogical *supellex*.

Then knowing the loss of *this* solid in distilled water at the given temperature, and also its loss in pump water at the same degree, and, dividing the latter by the former, you have the specific gravity of the pump water at the same degree.

2dly, The specific gravity of *pump* or other water being thus had, you may find what specific gravity the solids under examination would have in distilled water in the same temperature as that of the pump water in which their specific gravity is supposed to have been already obtained; by this analogy, as the specific gravity of distilled water at the given temperature is to that of pump water at the same temperature, so is the loss of the solid examined in pump water to the loss it would experience in distilled water: then dividing the weight in air by this loss, the specific gravity it would have had in distilled water at this temperature is obtained: after which the specific gravity it would have at 62° is found by the first analogy.

Mr. Brisson has determined with much accuracy the specific gravity of a great variety of minerals, but unfortunately he was ill informed of the true denomination of many of those substances, and neglected describing them, which renders his work in many cases of little use. He tells us in his preface, that he took them at 14° of Reaumur, but does not say whether he employed the true thermometer of Reaumur, or that improved by himself. I suppose, however, he meant the latter, as it is employed in the meteorological observations of Paris since the year 1761; in that case his 14° answer very nearly to 61° Fahr. In the following work the specific gravities of many minerals are given that were never before examined, as well as of a great number that had been examined, but not in all their varieties.

Mr. Werner, though he recommends an accurate determination when it can be obtained, divides in general all minerals into 1° *supernatant*, that is, that float on water. 2° *light*, viz. those whose specific gravity extends from 1, to 2,000. 3° *not remarkably heavy*, whose specific gravity extends from 2,000 to 4,000. 4° *heavy*, whose specific gravity extends from 4, to 6,000; and 5° *very heavy*, whose specific gravity exceeds 6,000. This gross determination may be learned by long experience of weighing them in the hand.

The most convenient instrument for taking specific gravities is that invented by Mr. Nicholson, of which a description may be seen in vol. ii. of the Memoirs of Manchester, or Mr. Magellan's improved edition of Cronstedt.

When the specific gravity of any stone is much inferior to that of the species to which it otherwise seems to belong, it were proper to reduce it to powder, and take its specific gravity in that state also.

Adhesion to the *tongue* and *fingers*, *Colour* of a *streak*, *Diffusion* in *water*, are easily understood.

As to the *Feel*, we may distinguish those that are *rough*, *smooth*, or *greasy*.

The *Smell* may be *sulphureous*, *bituminous*, *urinous*, or *earthy*.

The *Taste astringent*, *saline*, &c.

As to the *Refrigerating power*, that is, of impressing a sensation of cold when felt, though in general it is too vague to deserve notice, yet in some particular instances it may be useful to observe, that in the same temperature precious stones feel colder than the artificial or false gems, or other stones of the siliceous class; and these, than stones of the argillaceous or calcareous;

reous; and marble, than alabasters or gypsums; and traps or basalts, than serpentines.

Of the internal Properties of Minerals.

Of this sort are 1° their magnetic and electric properties.

2°, *Their relation to acids.* Their solubility therein, either partial or total, when entire or in powder, with or without heat, effervescence, change of colour, gelatination, &c.

3°. *Their relation to fire;* and 1°, *in low heats,* their decrepitation, discolouration, induration, loss of weight, phosphorescence, &c.; 2°, *in high heats,* the calcination, infusibility or fusibility, at different degrees measured by Mr. Wedgwood's Pyrometer, an instrument of indispensable utility in mineralogical researches; its scale commences at the heat at which iron is visibly red in the day time, that is, at about 1077 Fahr. and extends to 170° of his scale, and perhaps farther: each degree of Wedgwood is equal to 130 Fahr. above 1077. An idea of the heats it measures may be had by the following table:

Brass melts at	21°
Swedish copper	27
Fine silver	28
Fine gold	32
Least welding heat of iron	90
Greatest of ditto	95
Greatest of a common smith's forge	125
Heat of copper and brass founderies	140
Cast iron melts	130
Heat of iron founderies	150
Greatest heat of a good wind furnace	160

By the help of a large bellows, loaded with 130lb. weight, I raised in my forge a heat of 168° in less than half an hour.

Of *fusibility*, there are various degrees approaching more or less to vitrification.

The first or lowest degree is *emollescence*, or that degree of softness which alters the shape of the body; or, if the substance be in powder, produces *agglutination*. Opaque bodies by this heat become often slightly transparent at the edges.

The second *degree* is the *porcelain* state. In this some points are vitrified, but the greater number are not, and consequently the grain can be distinctly perceived; this also has its degrees. Some porcelains are destitute of lustre, and some have a slight glazing; on these last the fire has had a greater effect. Some porcelains are porous, and some compact.

The third is that in which the granular appearance is destroyed, but no transparency induced. Bodies in this state, if they are metallic and compact, are called *slaggs*, if porous *scoriæ*, if they have a vitreous gloss, *enamels*.

The 4th is that in which the substances acquire a semitransparency. And

The 5th, that in which they become completely transparent. Both enamels and vitrifications are sometimes compact, sometimes porous. Some substances are incapable of becoming either transparent or semitransparent.

The most commodious furnace for examining the effect of high heats on minerals is a forge furnished with a large bellows, loaded if necessary. The length of time which wind furnaces require to produce their full effect, is the cause that the substances frequently melt by being long in contact with the clay of the crucibles, whereas a forge may be brought to its full heat in less than an hour; and after the first experiment, which heats the hearth, in less than half an hour; and does not give time to the minerals under examination to act on the crucibles, as I have learned from repeated experience. Swansea coal I find the best. I call those bodies

Very easily fusible that melt at between 30° and 40° of Wedgwood; and

Easily fusible those that melt between 100° and 125°.

Moderately fusible when they melt between 125° and 135°.

Difficultly fusible when they require a heat of from 135° to 150°.

Very difficultly fusible when a heat from 150° to 165° is necessary for their fusion.

If platina crucibles be used they should be coated.

Mineral alkali, borax, and microcosmic salt, deprived of the water of crystallization, are the fluxes generally used. I seldom use any.

The heat of the blow-pipe rarely extends to 125°, and never exceeds 130° of Wedgwood.

The last of the internal characters of mineral bodies is determined by the products or rather educts of their analysis, of which I shall treat more amply in the sequel.

CHAP. IV.

AN IDEA OF THE CLASSIFICATION OF EARTHS AND STONES.

On the most general view of an indiscriminate heap of earths and stones, we may readily perceive that some have an *homogeneous* aspect; none of the parts of which their volume consists bearing the appearance of being composed differently one from the other.

Others on the contrary visibly involve two or more heterogeneous substances, either adhering to, or inhering one in the other: these are called *aggregates*.

Lastly, others seem to participate of the nature of two (or perhaps more) heterogeneous fossils, without however any visible separation of one from the other: these I call *derivatives*.

Thus we have three primary divisions of earths or stones,

In reducing each of these into minuter divisions, we naturally begin with the homogeneous as the most simple.

The *classification* of earths and stones consists in their arrangement in a certain order relatively to each other.

Order, when not arbitrary, necessarily supposes both *distinction* and *resemblance*. Without *distinction* all the bodies to be arranged would be equally entitled to the same place in the series. Without *resemblance* no reason could be assigned why a body should occupy one particular place rather than another place, there being no relation to connect it with the preceding.

Hence it follows, that those bodies which resemble each other most, should be grouped together; and, consequently, that there should be as many heads of general division as there are general grounds of resemblance.

If it be asked whence this resemblance should be taken; whether from the external or internal characters? I answer, it should be taken from both, it being the result of the joint consideration of both.

Now upon examining the *totality* of homogeneous earths and stones, it will be found that those resemble each other most that contain the largest proportion of the same *simple* earth, or most of the characterizing properties of the same simple earth; and, as there are *nine* simple earths, it follows that there must be *nine genera*, or primary divisions of homogeneous earths and stones.

In the same manner, under each head or *genus*, we may consider those substances as *specifically* different that resemble each other least, or that differ in some important property relatively to human uses; for systems being fabricated to help the memory, by pointing out the most important distinctions, and none being more so than those that are applicable to human uses, should never lose sight of their primary end and designation. I am well aware that some very eminent mineralogists would wish to reserve distinctions relative to practical utility, for a branch of mineralogical knowledge, which they intitle *Œconomical Mineralogy*; and when these distinctions are not of considerable importance, and would introduce confusion, I think they may be reserved for a separate work of that nature; but when they do not clash with other natural divisions, I would not hesitate to place them in the same rank; and in effect these same mineralogists allow potters earth, fullers earth, tripoli, &c. a place in what they esteem the natural system.

Hence 1°. The generic earths, combined with an acid, are specifically different from those that are not.

2°. The same generic earth, combined with different acids, forms different species.

3°. The same generic earth, combined with a *notable* proportion of one or more of the other earths, forms a different species from the same generic earth, either uncombined or combined with a less *important* proportion of other earths. I call a proportion *notable* or *important* when it introduces a considerable alteration in the external or internal characters of the compound. Thus such a proportion as induces a considerable change in the specific gravity, or in the fusibility of any substance, is notable or important; so in the calcareous genus such a proportion of foreign earth, or earths as would prevent it from burning to lime, is certainly of importance, and the distinction grounded in nature: so proportions that alter the fusibility of substances, with respect to the degree at which they are fusible, are certainly notable, and a good foundation for specific distinctions.

But varieties of proportion, or even of ingredients, that produce no notable change, either in the internal or external properties of a compound, make no alteration in the species; and in fact there are scarcely any earths or stones that have, strictly speaking, the same proportion of ingredients. Traps or basalts, and zeolytes, vary considerably.

4°. Any earth which forms less than one-twentieth of a compound is almost always of little importance.

5°. Water forms an important part of any compound when it exceeds one-twenty-fifth of the whole.

6°. Calces of iron influence in some measure the properties of a compound when they exceed one-thirty-third of the whole. If they are themselves magnetic, they communicate that property to compounds of which they form above one-tenth.

Species are further divisible from some particular points of agreement into *families*, or *classes* and families; sometimes it is necessary to form distinctions where specific characters are not decided; in which case I distribute the classes into *tribes* and families, as will be seen in the sequel. The minuter diversifications are called *varieties*. The term *specimen* corresponds with that of *individual* in the animal kingdom.

CHAP. V.

EXPERIMENTS ON THE FUSIBLE AND INFUSIBLE PROPORTIONS OF SIMPLE EARTHS.

As the fusibility of simple earths when mixed together in certain proportions, while those earths singly taken are infusible, forms one of the most surprising phænomena in natural philosophy, and one of the most important grounds of specific distinction among earths and stones in mineralogy, I have taken the pains of ascertaining, with more accuracy than has already been practised, the proportions and degrees of heat at which it takes place (many of which had never before been tried), and also the fusibility of mixtures in which an earth is introduced that never before had been essayed. These experiments are also productive of two capital advantages: 1. They lead to the knowledge of the composition of some minerals, of whose analysis we are as yet ignorant; and, 2

2dly, they serve as a test of the analysis already made; for it is plain, that analyses that assign a *fusible proportion* of ingredients to an infusible stone or earth, or an *infusible proportion* to one that is fusible, must be erroneous.

To promote these purposes as far as possible, it is necessary to introduce and set forth not only my own experiments, but all those of my predecessors in this enquiry, in which the proportions were ascertained with due accuracy, and the ingredients sufficiently pure. The experiments of Kenkel, who first remarked this phænomenon, do not appear. Mr. Pott made numerous and important experiments with compound stones and earths, but scarcely any on mixtures of the simple earths. M. D'Arcet and Macquer also scarcely ever employed any but compound substances. Mr. Achard seems only to have undertaken precisely the same task as I have; however, many of his experiments are liable to objections, which I shall presently mention.

Mr. Lavoisier has also examined, with the most scrupulous accuracy, the fusibility of most minerals in the heat excited in burning charcoal by pure air, instead of common atmospheric air, and also the fusibility of a few mixtures of some of the simple earths: this heat is so powerful as to prevent all difference in the degrees of fusibility from being perceived: in so much, that, from the fusibility experienced in this mode of applying heat, it does not at all follow that the same substances or proportions would be fused in the highest heat of our furnaces. But we may well draw this negative conclusion, that substances or proportions, which do not melt in the heat excited by pure air, are certainly infusible in the heat of our furnaces.

The experiments of Mr. Achard are made on mixtures in various proportions of calcareous, muriatic, argillaceous, and siliceous earths, taken two and two, three and three, and in some cases four and four.

To obtain the calcareous earth uncontaminated with any other, he dissolved chalk in the marine acid, distilled the solution to dryness, kept the residuum in red heat under a muffle for two hours, by which means the marine acid was expelled from every earth contained in the chalk, except the calcareous; this, by the affusion of water, he redissolved, and precipitated it by salt of tartar *; hence we see it was mild calcareous earth, and not lime, that he used in his experiments. Magnesia he procured from a purified solution of Epsom salt; and argill from a purified solution of alum, both by precipitation with a fixed alkali; the earth of alum, however, obtained by this means, always retains a portion of the alkali.

To procure pure siliceous earth, he melted the white sand of Freyenwalde with four times its weight of salt of tartar, and formed a *liquor silicum*, which he precipitated by vitriolic acid; the precipitate, after edulcoration, he digested in marine acid, until nothing more was dissolved; the residuum was pure siliceous earth.

The calx of iron he obtained by solution in nitrous acid, and precipitation by a fixed alkali; hence it was perfectly calcined.

These earths, mixed in the different proportions that will presently be mentioned, he exposed to the strongest heat of the royal porcelain furnace in Berlin, and left them in it as long as was necessary to bake the porcelain †.

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* Mem. Berl. 1779.

† Mem. Berl. 1780, 64.

What the heat of this furnace was cannot be directly ascertained, but may be collected from various circumstances. 1°. Mr. D'Arcet assures us, that the heat of a porcelain furnace exceeds even that produced in the focus of the best burning glasses: this, however, is not credible. Mr. Wedgwood, an irrefragable witness in matters of this nature, tells us that common Chinese porcelain softens at 120°, and sinks down at 156° of his pyrometer. It must therefore be baked in a much lower heat. Nankin indeed even resists this heat, but it seems the only sort that does; yet a good wind furnace affords a heat of at least 160°, much superior consequently to the highest porcelain heat. But, 2dly, Mr. Klaproth informs us, that the heat of the royal porcelain furnace of Berlin is capable of reducing manganese to a regulus, and therefore it must be at the least equal to 150°*, that being the heat necessary to melt down iron. Nevertheless, it may be doubted whether this furnace always produces this heat, as Mr. Achard assures us that he found a mixture of silex and calcareous earth infusible in all proportions †; and yet I found a mixture of equal parts of both fusible at 150°, and so did Swab, 2 Mem. Sued. p. 443; though possibly his failure in this instance might have proceeded from his having used mild calx, whereas Swab and I have used lime, and this appears to me most probable.

But the great defect of this mode of essaying the fusibility of earths, arises from the well grounded suspicion that their fusion is frequently procured by their action on the matter of the crucible, which furnishes them both with the argill and the silex, and consequently forms a mixture very different from that whose fusibility is intended to be explored. That the fusion of several earths and mixtures, essayed both by Mr. Achard and Mr. D'Arcet, arose from this cause, can scarcely be doubted. Mr. Achard found a mixture of two parts calcareous earths and one part magnesia vitrifiable *, yet Mr. Lavoisier, who tried their fusibility in a much higher heat, found them perfectly infusible in every proportion †, and I found a mixture of those subsances, in the proportion mentioned by Mr. Achard, to pass through the crucible. The length of time, during which they are exposed to heat, necessarily renders them liable to this accident, which is avoided by the brisk and sudden mode of heating them which takes place in a forge. Yet it must be allowed that action on the crucible can only take place where calx, or magnesia, or barytes, are employed, either alone or with a small proportion of argill and silex; and consequently the fusibility observed by Mr. Achard in other cases is above suspicion.

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* Chym. Ann. 1789, 11. † Mem. Berl. 1780, 32.

In my experiments the lime was formed of the purest Carrara marble. The magnesia was Henry's calcined, whose purity I never had cause to suspect. The silex was pure transparent crystal, heated to redness, quenched in distilled water, and then reduced to impalpable powder in a glass mortar, which it did not corrode. The barytes was the natural mild barytes. Of the calces of iron, I employed two sorts; one thoroughly calcined by solution in

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* Mem. Berl. 1780, 65.

† Mem. Paris 1783, 595, and 599.

the nitrous acid, and expulsion of the acid in a red heat; the other common rust, from which much of its water and fixed air had been expelled by heating it to redness. The heat was communicated in a forge, and never lasted above three quarters of an hour, and most commonly but twenty or twenty-five minutes. The results and the degree of heat will be seen in the following tables. To estimate the heat, I placed one of Mr. Wedgwood's pyrometers in a crucible nearly of the same size as that which contained the substances to be tried, and set both at an equal distance from the nozzle of the bellows.

To avoid prolixity, I suppress Mr. Achard's experiments when made on the same mixtures, and attended with the same results; when they are mentioned, they are marked [*A.*]

TABLES

OF THE FUSIBILITY OF THE SIMPLE EARTHS MIXED IN VARIOUS PROPORTIONS, IN HEATS NOT EXCEEDING 166° OF WEDGWOOD.

Calx and Magnesia.	Heat.	1°. Of Binary Proportions.
50 parts calx 50 magnesia	150°	melted, only where in contact with the crucible, into a grey, partly vitrified and partly porcelain mass. Per Lavoisier also they melt in no proportion; and also Bergm. 372.
80 calx 20 magnesia	150	went through the crucible,
75 calx 25 magnesia	160	went through the crucible.
66 calx 33 magnesia		went through the crucible.
80 magnesia 20 calx	165	did not melt but where in contact with the crucible, which it slightly corroded and blackened.
66 magnesia 33 calx	138	did not melt but where it touched the crucible.
30 calx 10 magnesia	156	melted into a fine greenish yellow glass, but the crucible was corroded throughout.
Calx and Barytes.		infusible in all proportions per Lavoisier.
Calx and Argill. 88 calx 12 argill		infusible even by the heat of pure air. Ehrm. § 208.

Calx

Calx and Argill.	Heat.	Of Binary Proportions.
75 calx 25 argill	150	not melted, except where in contact with the crucible it formed a compact porcelain brownish red mass.
66 calx 33 argill	150	remained a powder. Hence the contrary results obtained by Achard seem to proceed from the action of the mixtures on the silex of the crucible. Mr. Bergman also found calx and argill infusible in all proportions. 4 Berg. 337, and Macquer. Mem. Paris, 1758, 356 in 8vo.
66 argill 33 calx		melt by pure air. Ehrm. § 208. infusible, per Achard, Mem. Berl. 1780, 65.
75 argill 25 calx		melt by pure air, ibid; infusible, per Achard, ibid.
80 argill 20 calx		melt by pure air, ibid; infusible, Achard, ibid.
50 calx 50 argill		infusible, Achard, loc. cit. and formed only a loose powder in this as in the former cases.
Calx and Silex.		
50 calx 50 silex	150	melted into a mass between porcelain and an enamel; white, glazed on the surface, semitransparent at the edges, and gave fire with steel, though feebly. Yet Mr. Achard found them infusible in every proportion, perhaps because his calx was mild.
50 calcareous spar 50 quartz		melted by pure air, Lavoisier; but by continued heat, became less fusible.
80 silex 20 calx	156	not melted, formed a brittle mass.
80 calx 20 silex	156	formed a yellowish white loose powder.

	Heat.	Of Binary Proportions.
Barytes and Magnesia.		do not melt in any proportion even by pure air.
Barytes and Argill.		
80 argill 20 barytes	150	scarcely hardened.
75 argill 25 barytes	156	no sign of fusion, a loose powder.
66 argill 33 barytes	152	as the former.
50 argill 50 barytes	150	as the former.
80 barytes 20 argill	148	somewhat harder, but no sign of fusion.
75 barytes 25 argill	150	harder, but no sign of fusion.
Barytes and Silex.		
80 silex 20 barytes	155	formed a white brittle mass.
75 silex 20 barytes	150	a brittle hard mass semitransparent at the edges.
66 silex 33 barytes	150	melted into a hard somewhat porous porcelain mass.
50 silex 50 barytes	148	a hard mass not melted.
80 barytes 20 silex	148	the edges were melted into a pale greenish mass, between a porcelain and an enamel.
75 barytes 25 silex	150	melted into a somewhat porous porcelain mass.
66 barytes 33 silex	150	melted into a yellowish and partly greenish white porous porcelain.
Magnesia and Argill.	150	these were not tried by Mr. Achard: in my trials they had no action on each other in whatever proportion they were used.

	Heat.	Of Binary Proportions.
Magnesia and Silex.		
50 magnesia 50 silex		melt with great difficulty even in the heat of pure air. Mem. Par. 1787, p. 598, into a white enamel; but in inferior heats they are infusible in all proportions by the experiments of Achard, Mem. Berl. 1780, 33, and Margr. 1778, 4, and 1 Bergm. 372.
Argill and Silex.		
50 argill 50 silex	160	barely hardened, but no sign of fusion. Mr. Lavoisier found a mixture of equal parts quartz and argill vitrifiable by pure air. But this experiment is suspicious, as the quartz he used was more fusible than pure crystal, and consequently impure. In a porcelain heat Mr. Achard found them infusible in all proportions; and Bergm. 337.
Iron highly calcined and Calcareous Earth.		According to Mr. Achard's experiments, they melt at least into a porcelain mass, in every proportion, not exceeding 4 parts of the one to 1 of the other; but those mixtures, in which the calces of iron exceed the calcareous earth, are by far the most fusible.
Iron fully calcined and Magnesia.		
A 80 magnesia A 20 calx iron		infusible, Achard, Mem. Berl. 1779, 53.
75 magnesia 25 calx of iron	155	remained a brownish black powder. Mr. Achard had the same result.
A 66 magnesia A 33 calx of iron		remained a brown mass.

CALX of IRON and MAGNESIA.	Heat.	Of Binary Proportions.
A 10 magnesia 50 calx of iron		hardened, but did not melt.
A 80 calx of iron 20 magnesia		melted, and passed through the crucible.
A 75 calx of iron 25 magnesia		half melted.
A 66 calx of iron 33 magnesia		half melted.
IRON fully calcined and BARYTES.		
80 barytes 20 calx of iron	155	melted into a partly brownish and partly reddish shining slagg.
75 barytes 25 calx of iron	150	melted into a black bright foliated substance, resembling horneblende or an iron ore.
66 barytes 33 calx of iron	150	melted into a hard black compact mass, partly of a metallic and partly of a glassy appearance.
75 calx of iron 25 barytes	156	melted into a compact metallic slagg.
66 calx of iron 33 barytes	150	melted into a brownish black slagg, rather compact; much of the barytes seemed to have sublimed, as the cover and upper part of the crucible received a beautiful metallic white glaze.
IRON fully calcined and ARGILL.		
80 argill 20 calx of iron	160	remained a powder. Mr. Achard had the same result.
75 argill 25 calx of iron	160	remained a powder. Mr. Achard found it somewhat more inclined to melt.
66 argill 33 calx of iron	166	a pale reddish powder. Mr. Achard found it more inclined to melt.
50 argill 50 calx of iron	160	a yellowish-red powder. Mr. Achard found it more inclined to melt, and greyish black.

Iron fully calcined and Argill.	Heat.	Of Binary Proportions.
80 calx of iron 20 argill	160	melted into an opake porous black slagg. Mr. Achard also found a black porous mass which pierced through the crucible.
75 calx of iron 25 argill		This experiment failed with me. Mr. Achard found a porous melted mass.
66 calx of iron 33 argill		this also failed with me. Mr. Achard found a porous melted mass; but the crucible was much corroded.
Iron fully calcined and Silex.		
A 80 silex 20 calx of iron		seemingly melted black and friable; yet I believe it was not melted, otherwise the next mixtures must have been so.
A 75 silex 25 calx of iron		not melted, black and friable.
A 66 silex 33 calx of iron		not melted, black and friable.
A 50 silex 50 calx of iron		slagg.
A 80 calx of iron 20 silex		melted into a porous slagg that pierced the crucible.
A 75 calx of iron 25 silex		melted, and pierced through the crucible.
A 66 calx of iron 33 silex		melted, and pierced through the crucible. Hence we see that the compounds of silex and calx of iron, in which the iron exceeds, act on argill.
Rust of Iron and Lime.		
90 lime 10 rust	125	a broad hard mass. began to act on the crucible.
80 lime 20 rust	125 150	a hard brown mass. a liver-brown porcelain mass.

Rust

	Heat.	Of Binary Proportions.
Rust of Iron and Argill.		
50 argill 50 rust	156	formed a greenish black loose powder.
Rust of Iron and Silex.		
90 silex 10 rust	150	a yellowish brown indurated brittle mass.
80 silex 20 rust	125	not melted, but formed a brown hard mass.
75 silex 25 rust	150	a brown hardened powder.
66 silex 33 rust	150	a blackish brown indurated powder.
Argill and Metallic Iron.		
50 argill 50 metallic iron	160	melted into a hard greyish black mass; but other proportions, in which the argill exceeded, I found infusible at 160.

Ternary Proportions, the first in greatest quantity.

Calx, Magnesia, and Argill.

A	3 parts calx 3 argill 1 magnesia	porous porcelain mass.
A	3 calx 2 argill 1 magnesia	powder.
A	3 calx 1 argill 1 magnesia	powder.
A	3 calx 3 argill 2 magnesia	somewhat porous porcelain.
A	3 calx 2 argill 2 magnesia	powder.

3 calx

$$A\left\{\begin{array}{l}\text{3 calx}\\\text{3 magnesia}\\\text{2 argill}\end{array}\right\}\text{powder.}$$

$$A\left\{\begin{array}{l}\text{3 calx}\\\text{2 magnesia}\\\text{1 argill}\end{array}\right\}\text{vitrified.}$$

MAGNESIA, CALX, and ARGILL.

No compound, in which the magnesia exceeds the other two ingredients, is fusible.

ARGILL, CALX, and MAGNESIA.

$$A\left\{\begin{array}{l}\text{3 argill}\\\text{2 calx}\\\text{1 magnesia}\end{array}\right\}\text{a porcelain.}$$

$$A\left\{\begin{array}{l}\text{3 argill}\\\text{2 magnesia}\\\text{1 calx}\end{array}\right\}\text{a porcelain.}$$

$$A\left\{\begin{array}{l}\text{3 argill}\\\text{3 magnesia}\\\text{1 calx}\end{array}\right\}\text{porous porcelain.}$$

$$A\left\{\begin{array}{l}\text{3 argill}\\\text{3 magnesia}\\\text{2 calx}\end{array}\right\}\text{porous porcelain.}$$

$$A\left\{\begin{array}{l}\text{3 argill}\\\text{2 calx}\\\text{2 magnesia}\end{array}\right\}\text{porcelain.}$$

CALX, MAGNESIA, and SILEX.

$$A\left\{\begin{array}{l}\text{3 calx}\\\text{3 silex}\\\text{1 magnesia}\end{array}\right\}\text{powder.}$$

$$A\left\{\begin{array}{l}\text{3 calx}\\\text{1 silex}\\\text{1 magnesia}\end{array}\right\}\text{green glass.}$$

$$A\left\{\begin{array}{l}\text{3 calx}\\\text{2 silex}\\\text{1 magnesia}\end{array}\right\}\text{green glass.}$$

A	3 calx 3 silex 2 magnesia	porcelain or enamel.
A	3 calx 2 magnesia 1 silex	porous enamel.
A	3 calx 2 magnesia 2 silex	porcelain.
A	3 calx 3 magnesia 1 silex	between a porcelain and an enamel.
A	3 calx 3 magnesia 2 silex	an enamel, texture striated.
A	2 calx 2 magnesia 1 silex	powder.
A	1 calx 1 magnesia 1 silex	greenish glass.
A	2 calx 2 silex 1 magnesia	opalescent glass.
A	2 calx 1 silex 1 magnesia	greenish glass.

MAGNESIA, CALX, and SILEX.

No compound, in which the magnesia predominates, melts; but, when it barely equals either, it may form a porcelain.

SILEX, CALX, and MAGNESIA.

A	3 silex 1 calx 1 magnesia	powder.
A	3 silex 2 calx 1 magnesia	porous porcelain.

A	3 silex 2 magnesia 1 calx	powder.
A	3 silex 2 calx 2 magnesia	powder.
A	3 silex 3 magnesia 1 calx	powder.
A	3 silex 3 magnesia 2 calx	harder powder.
A	2 silex 1 calx 1 magnesia	enamel.
A	2 silex 2 magnesia 1 calx	hard powder.

MAGNESIA, ARGILL, and SILEX.

1. No compounds, in which magnesia predominates, will vitrify or form a porcelain.

2. A compound, in which it equals each of the other two, will not form even a porcelain. Per Achard.

ARGILL, MAGNESIA, and SILEX.

A	3 argill 3 silex 1 magnesia	porcelain.
A	3 argill 1 silex 1 magnesia	powder.
A	3 argill 2 silex 1 magnesia	hardened only.
A	3 argill 3 silex 2 magnesia	porcelain.

3 argill

A	3 argill 2 magnesia 1 silex	hardened only.
A	3 argill 2 silex 2 magnesia	porous porcelain.
A	3 argill 3 magnesia 1 silex	powder.
A	3 argill 3 magnesia 2 silex	porcelain.
A	2 argill 2 magnesia 1 silex	hardened only.

SILEX, MAGNESIA, and ARGILL.

A	3 silex 1 argill 1 magnesia	slightly porcelain.
A	3 silex 2 argill 1 magnesia	hardened only.
A	3 silex 2 magnesia 1 argill	greenish glass.
A	3 silex 2 argill 2 magnesia	hardened only: yet, quere; for afterwards, he allows it to have melted to a porcelain. See Berl. Mem. 1780, pp. 38, 39.
A	3 silex 3 magnesia 1 argill	porcelain.
A	2 silex 2 argill 1 magnesia	nearly porcelain.
A	2 silex 1 argill 1 magnesia	porcelain.

CALX,

CALX, ARGILL, and SILEX.

A	3 calx 3 argill 1 silex	green glass.
A	3 calx 1 argill 1 silex	green glass.
A	3 calx 2 argill 1 silex	friable mass.
A	3 calx 3 argill 2 silex	porous enamel.
A	3 calx 2 silex 1 argill	greenish glass.
A	3 calx 2 argill 2 silex	between a porcelain and an enamel.
A	3 calx 3 silex 1 argill	greenish glass.
A	3 calx 3 silex 2 argill	greenish glass, nearly white.
A	2 calx 2 argill 1 silex	hardened only.
A	2 calx 1 argill 1 silex	greenish porcelain.
A	2 calx 2 silex 1 argill	greenish porcelain.

ARGILL, CALX, and SILEX.

A	3 argill 1 calx 1 silex	very hard only.
A	3 argill 2 calx 1 silex	friable mass.

3 argill

A	3 argill 2 silex 1 calx	porous porcelain.
A	3 argill 2 calx 2 silex	semitransparent, half vitrified.
A	3 argill 3 silex 1 calx	reddish porcelain.
A	3 argill 3 silex 2 calx	yellow and semitransparent.
A	2 argill 1 silex 1 calx	friable mass.
A	2 argill 2 silex 1 calx	greenish porcelain.

SILEX, ARGILL, and CALX.

A	3 silex 3 calx 1 argill	greenish white glass.
A	3 silex 3 argill 2 calx	yellow enamel.
A	2 silex 1 argill 1 calx	greenish porcelain.

71 silex 24 argill 5 calx	at 145° it barely hardened. at 153 it formed a porous porcelain, glazed only at the surface.
63 silex 32 argill 5 calx	at 145 barely hardened. at 153 a somewhat porous porcelain.
67 silex 23 argill 10 calx	at 145 melted into a porous frothy enamel, semitransparent.
60 silex 30 argill 10 calx	at 135 formed a frothy semitransparent enamel.
57 silex 38 argill 5 calx	at 135 formed a porous porcelain.

54 silex

54 silex 36 argill 10 calx	at 135 a frothy semitransparent enamel.

Miscellaneous Experiments.

40 argill 25 silex 20 aërated calx 1,3 highly calcined iron	barely coalesced at 144° into a grey mass, glazed on the surface. *Same mixture*, with the substitution of 13 calx of iron, instead of 1,3, which is the *hyacinth of Bergman*, melted at 144° into a reddish porous slagg.
46 argill 39 silex 8 aërated calx 6 highly calcined iron	*Saxon topaz* of Bergman, melted at 144 into a greyish slightly porous porcelain mass.
41 argill 34 silex 20 rust of iron	*shorl* of Wiegleb melted at 148 into a porous black slagg, with a strong metallic appearance. *ditto* with *highly calcined iron*, formed a greenish black porous slagg, ill melted.
46,66 silex 48,5 magnesia 4,75 rust of iron	*asbestos* of Wiegleb, a reddish yellow, somewhat indurated, powder, except where it touched the crucible, which it corroded at 148.
43 silex 22 magnesia 34 rust of iron	the *actinolite, or Strahl stein,* of Wiegleb, melted into a greyish black, somewhat porous and fibrous, mass, perfectly opaque, at 148.
67 silex 14 argill 11 barytes 8 magnesia	*felspar*, by my analysis, melted at 148 into a white porous enamel.
65 silex 32 argill 2 calx of iron	*felspar* of Wiegleb refused to melt even at 158, and barely hardened.
43 silex 37 argill 1,7 calx 4 calx of iron	*felspar* of Saussure refused to melt at 140, formed a hard porous mass.

37 silex 22 argill 16 magnesia 23 rust of iron 2 calx	*hornblende*, by my analysis, melted into a black compact glass at 156°.
41 silex 16 calx 17,5 magnesia 17,5 calx of iron	*hornblende* of Wiegleb melted at 137° into a greenish black glass.

Corollaries.

Hence it follows, 1. that all binary combinations of the five earths are infusible, and in every proportion, under 166°, except two: 1st, *calx* and *silex*, in equal parts, and in a heat not under 150°, and in that only into an enamel; and, 2dly, *silex* and *barytes:* these appear to act on each other in a heat not below 150°, where the silex is to the barytes in the proportion of 3 to 1, or 2 to 1; or the barytes to the silex in the proportion of 4 to 3, or 2 to 1, but scarcely when they were in equal quantities.

2. With respect to calces of iron and the five simple earths, we may observe, first, that where the lime *exceeds the calx of iron* even in the proportion of 9 to 1, it is so far affected by it as to be converted into a porcelain in a heat of 150°, and then begins to act on the argill or silex of the crucible. When the lime is in the proportion of 4 to 3, or 2 to 1, the compound is yet more fusible, but still only into a porcelain: yet Mr. Achard found it to crystallize, which argues a farther degree of fusion.

But if the calces of iron exceed the lime in the proportion of 4 to 3, or 2 to 1, the compounds are still more fusible, and pass through the crucible, which shews they have a strong action on the argill or silex, or both.

2dly. With regard to *barytes* and *calces of iron*, I found them to act on each other much more powerfully than lime and calces of iron: at 150°, they melt in every proportion from 4 to 1 of either. Other proportions have not been tried.

3dly. As to *magnesia* and *calces of iron*, Mr. Achard found that, where the magnesia exceeds the calx of iron, they have no action on each other, at least at 150°, nor even when they are in equal quantities: but, when the calces of iron exceed the magnesia as 4 to 1, they melt perfectly; when only as 3 to 1, they melt less perfectly; and when as 2 to 1, still less perfectly.

4thly. With respect to *argill* and *calces of iron*, in my own experiments, when the argill exceeded the calces of iron, I observed no tendency to fusion even in heats from 160° to 166°, nor even when they were in equal proportions; but, when the calces of iron exceeded the argill in the proportion of 4 to 3, or 2 to 1, the compound was fusible apparently in the same proportion, that is, most when 4 to 1, &c.; when I used rust, *i. e.* semicalcined iron, the compound was greenish. The heats from 156° to 160°.

5thly. As to *silex* and *calces of iron*, it appears, that they are infusible when the silex exceeds; but if the calces exceed, the compound will be fusible.

Of Ternary Combinations.

Calx, Magnesia, and Argill, at 150°.

1. No compound of these, in which magnesia predominates, will melt in any degree in a heat below 166°.

2. No compound of these, in which calx predominates, will vitrify, except they lie in the proportion of 3 calx, 2 magnesia, and 1 argill. Proportions approaching to this may give porcelains or enamels.

3. Pro-

3. Proportions, in which the argill equals either, and exceeds the other as 3 to 1, may form porcelains at 150°.

Calx, *Magnesia*, and *Silex*, at 150°.

1. If the calx exceeds, these may afford several fusible compounds.
2. If the magnesia exceeds, they will afford no fusible compound.
3. If the silex exceeds, they afford few fusible compounds.

Argill, *Magnesia*, and *Silex*, at 150°.

1. If the argill exceeds, nothing more than a porcelain can be produced.
2. If the magnesia exceeds, not even an imperfect fusion can be had.
3. If the silex exceeds, a porcelain may be produced in several instances, and a glass in one, namely, when they are in the proportion of 3 silex, 2 magnesia, and 1 argill.

Argill, *Calx*, and *Silex*.

1. If the calx exceeds, either a glass, a porcelain, or an infusible mass, may arise, according to the proportion.
2. If the argill exceeds, a porcelain may in many cases be obtained, but not a glass.
8. But if the silex exceeds, a porcelain or enamel is frequently obtainable, probably also a glass, for the heats I tried were not very high.

Of Calces of Iron.

Compounds, that owe their fusibility to calces of iron, have always the appearance of a slagg.

CHAP. VI.

CALCAREOUS GENUS.

UNDER this head I comprehend all those earths and stones, apparently homogeneous, in which calcareous earth predominates.

1st *Species.—Native Lime.*—Whether this really exists has been much questioned; its existence, however, is not naturally improbable, since several stones contain uncombined calx, as appears by various analyses; and that lime once formed may remain a long time uncombined, even though exposed to the atmosphere, is evident from common experience. I have found lime in limekilns, of which a great part remained unsaturated four years after it was burned; but several respectable testimonies establish its real existence. Dr. Woodward tells us, that a whitish gritty earth, found at Clipstone stone-pit in Northamptonshire, was found by Dr. Moreton to contain lime, and make a cement, by barely mixing it with water. Dr. Falconer of Bath, a man of unquestionable skill and judgment in matters of this nature, informs us, that he observed a soft whitish stone in the neighbourhood of that town, containing a quantity of uncombined calcareous earth, and capable of dissolving sulphur. According to Mr. Monnet, it is found in great quantity on the mountains of Upper Auvergne that form the valley of Vic; it is there of a yellowish colour, being mixed with calx of iron. He thinks it of volcanic origin*; it is easily discovered by the taste, or solution in water and precipitation by the solution of corrosive sublimate in the form of a reddish powder.

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* Woodward's Catal. 7. 1 Falconer on Bath Waters, 156, 257. Monnet, Mineralog. 515.

2nd Species.—Combined with fixed air, aërated or mild calx.

Carbonate de Chaux.—This species presents such varieties both in colour, form, texture, and other external characters, and is liable to such numerous and important contaminations from other substances, that it is exceeding difficult, if not impossible, to establish such lines of separation between the different distinctions that precision requires, as shall not in some instances be confounded, and include those that were meant to be excluded. The distinctions I introduce are therefore not always absolutely exact, but those that upon the whole appear to me the clearest and most important.

All the substances included under this head effervesce with acids, and do not include above 12 or 15 per cent. of foreign combinations.

1*st Class.*—Mild calx in a loose or semi-indurated form.

1*st Family.*—*Agaric Mineral,* bergmilch or bergmehl of the Germans.

1*st Variety.*—*Dusty;* bergmilch of Werner: its colour is white red, or yellow formed of compacted particles, but exceeding friable, and hence dusty: feels dry, does not adhere to the tongue, and so light as nearly to float on water: gives no gloss to the skin.

2nd Variety.—*Somewhat unctuous;* white, formed of scaly particles, adheres to the tongue, very friable, feels somewhat greasy, and gives a gloss to the skin when rubbed on it, falls to dust in water, entirely soluble in nitrous acid, almost floats on water. *Lazius Hartz,* 228.

Both these varieties are found in the clefts of rocks, or at the bottom of some lakes.

3d Variety.—Silvery Chalk.—Of this I find some, but an imperfect, account in Crell's Annals for 1790. Its colour is silvery white, and in its structure it resembles mica; it feels soft and somewhat unctuous like talc, it is almost entirely soluble in nitrous acid, and the solution has all the properties of a solution of calcareous earth; it scarcely differs, as it seems, from the foregoing.

2nd Family.—Chalk.

White, or yellowish white.
Lustre 0.
Transparency 0.
Fracture earthy.
Fragments 0.
Hardness 3. 4.

Specific gravity of a specimen that did not moulder in water 24 hours 2.315. Dr. Watson found that of coarse hard chalk 2,657.

Adheres slightly to the tongue.

Feels dry and somewhat rough.

Stains the fingers and marks.

It slowly falls to pieces in water, and thence into powder, but some moulder very readily.

I found common chalk to lose 3 per cent. of its weight in a heat of 500 Fahr. and by solution in acids 0,42; the residuum, which is chiefly argillaceous, dried in the same heat, weighed about 2, sometimes 3 per cent. 100 parts chalk therefore contain about ,95 of mild calx, 2 of argill, and 3 of water; or 53 mere calcareous earth, 42 of fixed air, 2 of argill, and 3 of water.

Chalk in general is infusible even by the heat of pure air; but that of Boulogne (frequently mentioned by French writers) is fusible, Ehrm, § 209; therefore not so pure as that found in other places.

Mr. Rinman, Hist. Ferri. § 201, mentions a blue chalk found in the neighbourhood of Upsal; it contains iron.

According to Mr. Lavoisier[*], 100 parts chalk contain 52,603 of pure lime, 31,949 of fixed air, and 15,402 of water; but this large proportion of water is barely inferred from the quantity absorbed and retained by quick-lime in a heat of 600° Fahr. and which he supposes must also be contained in chalk, a supposition that seems to me inadmissible, as lime has a stronger affinity to water, and retains more of it than aërated calx has, or can retain. Besides, by his own first experiment, 1404 grains of chalk lose by solution in nitrous acid 576 grains, that is, at the rate of 41.025 per cent. which is farther confirmed by the quantity of air given out in that experiment, viz. 800 French cubic inches in the temperature of between 16° or 17° of Reaumur, barometer at 28 French inches nearly. Now by his own rules of reduction, 800 cubic inches, at the temperature of 16°, 5 Reaumur, would make but 775,24 cubic inches at 10° of Reaumur, and these would weigh by his rule of estimation 552,88 grains, which amounts to 39,47 per cent.

3d Family.—Arenaceous limestone. *Ganil.*

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[*] 1 Lavoisier, 201.

This is so called from its brittleness, and not from its containing sand.

The colour of the specimens I have seen was yellowish white.

Lustre 1, from a few shining particles.

Transparency 1.

In the lump it cannot be broken but by a hammer, but small pieces of it fritter between the fingers.

Its specific gravity 2,742. It phosphoresces when scraped with a knife in the dark, but not by laying on a hot iron.

It contains 47 per cent. of fixed air, and is almost entirely soluble in nitrous acid. It was found on the shores of Rhaghery, a small island of the coast of Antrim, by my ingenious friend Dr. Hamilton; its name in the Irish language purports limestone in the form of sand. Another specimen, exactly resembling it, was found at Codrilla, on the west side of Vesuvius, and presented to me by that very accurate observer the Rev. Mr. Graydon. It has also been discovered on the summit of Mount Gothard, in Switzerland: this last phosphoresces when laid on burning coals, yet contains no acid but fixed air. 2 Chy. Ann. 1790, 132.

I have met with another specimen of this stone, which exactly resembles that which I have described, except that its specific gravity is but 2,691, and that it has not the phosphorescing quality. It contains but 42 per cent. of fixed air. Does not the phosphorescing property, therefore, originate from the large proportion of this air?

4th Family.—Testaceous Tufa. See Leske, § 527, 562, 571.

1*st Variety.*—White or yellowish white, exceeding porous and brittle, formed of various broken shells compacted together, found in the neighbourhood of Syracuse, Palermo, and the promontory of Passoro in Sicily. *Borch Lithologie des Siciliens*, 287.

2nd Variety.—Marly Tufa.—This is also lowish white,, resembling mortar, and frequently contains small shells, destitute of lustre and transparency, and very porous; its fracture earthy, its hardness from 6 to 8. See the specimen, *Leske*, § 571.

3d Variety.—Stalactitic Tufa.—This consists of whitish grey fistulous concretions variously ramified or compacted together, or of brownish grey concretions resembling moss; both exceeding light and brittle, devoid of lustre and transparency; their fracture earthy hardness, from 6 to 7.

Second Class.—Indurated.

1st Family.—Compact Limestone.—This term is here taken in a technical sense to express a particular fracture already explained.

Its colour is usually grey, blended with various shades of other colours, as dark or light grey, bluish grey, yellowish grey, pearl grey, blackish grey, less commonly greyish white, Isabella yellow or ochre yellow, or flesh or brownish red, or greenish grey, or greyish black; often with many of these colours together in blotches, veins, stripes, or specks.

It frequently abounds with impressions or petrifactions of muscles, snails, corals, pectinites, gryphites, mytulites, &c.

Its lustre 0, or barely 1, from a few shining particles; its transparency 0, rarely 2. Its fracture compact, most commonly splintery, coarse or fine, rarely passing to the conchoidal;

sometimes uneven, sometimes earthy, rarely slaty.

Its fragments 2.

Its hardness from 5 to 8, rarely 9*, except mixed with quartz.

Its specific gravity 1,3864 (before absorption of water) to 2,72. Those that have their specific gravity below 2,4 are exceeding porous.

Effervesces with acids, and thus loses from 0,38 to 0,42 of its weight.

Burns to lime. Dr. Higgins has remarked that limestones kept ever so long in a red heat lose only one-fourth of their weight; in a heat that melts copper they lose about one-third; and in a heat that melts cast iron, that is, from 120° to 130° Wedgwood, they lose as much as they can lose, that is, from 38 to 44 per cent.

All these stones contain some slight contamination from other stones, argill, or iron, amounting at most to about 10 or 12 per cent.; if more than 15 the limestone is so notably degraded as scarcely to afford lime, and should then be excluded from the species we here consider: these contaminations are really less than 2 or 3 per cent. The carbonaceous principle should also be reckoned among them; for, as Dr. Higgins observes, limestones, calcined in vessels that do not allow a free communication with the air, afford a grey lime from some mixture of the coaly principle that remains unconsumed. Hence also limestones lose less of their weight when distilled in a retort than when burned in an open fire.

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* Mr. Anderson, in a valuable tract on limestones, mentions some found in Sunderland, which in external appearance resemble flints, and give fire with steel, yet burn to lime as pure as that of chalk. Essays on Agriculture, vol. ii. p. 188.

Variety 1.—*Those of splintery fracture.*—Their colour is generally grey, bluish grey, or greyish blue; their hardness from 7 to 8, and their specific gravity from 2,6 to 2,72.

Of this sort is the greyish blue limestone of Dublin; it is perfectly opaque; its specific gravity 2,708; it does not imbibe water, at least in 24 hours; it contains 0,41 of fixed air, and 0,03 of a mixture of blue argill and iron; it gives an earthy smell when breathed on.

The limestone of Paris contains 8 per cent. of argill, quartz, and iron. Dijonval, 142.

Variety 2.—*Those of conchoidal fracture.*—These are generally Isabella yellow, or dark blackish grey, or yellowish or reddish brown. Most of those I have seen are, however, so mixed with argill as rather to pass for marlytes; but, if the fracture be uneven and imperfectly conchoidal, they are purer from argill: the colour of these is bluish or greyish blue black; of this sort is the specimen, Leske, O. 1232; see also N. 1212 and 1220.

Variety 3.—*Of an earthy fracture.*—Their colour is generally white or light grey, or greyish, yellowish, or reddish white, or reddish brown, They are all porous, and some exceeding porous, and hence they absorb from about one-fourth to one-thirtieth of their weight of water; their specific gravity is therefore variable, being different both before and after absorption, and the difference proportioned to the quantity absorbed. The lightest stone of this sort I have read of has its specific gravity 1,3864, and after absorption 1,7528: it therefore absorbed above one-fourth of its weight of water. It is dug in the quarry of Bourré near Montrichard, in the neighbourhood of Tours: its colour is white, very soft, and fine grained.

grained *. The density of the heaviest scarcely exceeds 2,55. The hardness of these stones is from 5 to 7.

Portland stone, whose specific gravity is 2,461, and Bath stone, whose specific gravity is 2,494, belong to this variety, as does Ketton stone, whose colour is reddish brown, and consists of small rounded particles compacted together like the roe of fish: its specific gravity 2,456. It contains 90 per cent. of mild calx and 10 of argill, with a minute quantity of calx of iron. It seems the same as the *cenchrites*, 4 Crell Boytr. 432.

Several calcareous depositions, some even from Carlsbad, belong to this variety; some present a number of rounded depressions in their fracture; those which I have seen were either white or brick red.

Compact limestones often pass into marl. See Leske, G. 734, 735, and S. 1357; but it first grows slaty.

Variety 4.—Of a slaty fracture.—Under this head I comprehend those whose single laminæ have a compact fracture, but upon the whole slaty. Of this sort are,

1. The calcareous flagstones of Woodstock. Its colour is light bluish grey, or yellowish, powdered over with small reddish white round particles of a farinaceous appearance. The laminæ are of about one-tenth of an inch in thickness, and are themselves of a compact fracture. Its specific gravity from 2,585 to 2,614. It affords about 0,34 grains of air, which had somewhat of an hepatic or putrid smell. It contains a mixture of silex, argill, and iron; and hence gives fire with steel, though with difficulty. Its lustre 0, transparency 0; but its

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* Brisson, p. 259.

impurities are not sufficient to render it fusible, at least at 130°.

2. Limestones, of an Isabella yellow colour, frequently bearing vegetable impressions. The laminæ of these are frequently from one-fourth to three-fourths of an inch in thickness, and present a somewhat conchoidal fracture; that in Leske, O. 1240, burned to lime at 120°. See also G. 354, 355.

3. Limestones, of a light bluish grey colour, whose laminæ present a splintery fracture, as in Leske, S. 1357. These pass into marls for the most part.

The yellowish grey limestone, Leske, S. 961, is both sandy and slaty.

4. Granular limestones are also sometimes slaty, but much more rarely. See a specimen of this sort in Leske, S. 1326.

2nd Family.—Foliated and *granular.*—Its most usual colours are white, or light grey, or yellowish, greenish, or reddish white; seldomer reddish brown, flesh-coloured, or bluish grey, or greyish black.

Its lustre 2,1; transparency 2. 1,5, of the darker sorts 1.

Its fracture foliated, often very small and fine, always straight, sometimes in the gross slaty.

Its fragments 2.

It presents granular distinct concretions, often so small and fine, that the foliated texture is difficultly discerned.

Its hardness from 7 to 8; its specific gravity from 2,71 to 2,8376; where the density is higher, it is impure.

It scarcely ever contains petrifactions, or impressions of marine exuviæ.

Many of these effervesce very slowly with acids, as will be seen in the sequel.

Parian marble is said to be the purest stone of this family. Its colour is pure white. Its specific gravity, according to Brisson, 2,8376. Carrara marble is next in purity. I found it to contain about 0,45 of fixed air, and 0,03 of argill, with minute quartz crystals. Its specific gravity 2,717.

Mr. Cronsted, in the Memoirs of Stockholm for the year 1763, tells us he met in Iemptland a black thin slaty limestone, of a sparry texture, which, from its external appearance, would scarcely be taken for limestone, and yet afforded excellent lime. In some places it was dark grey, and undulatingly slaty.

Mr. Woulfe presented me with another of the slaty kind from Scotland; its colour dark bluish grey; its lustre 1; transparency 1; fracture, thick slaty. The laminæ about the thickness of an inch; their surfaces strewed over with mica. Fracture of the laminæ, granularly foliated, yet mixed with the splintery. Fragments 3; hardness from 8 to 9; specific gravity 2,718.

Some limestones are at the same time both granular and fine splintery, as may be seen in the specimen, Leske, O. 1254, which is of a beautiful bluish grey colour; and some conchoidal, and exceeding minutely foliated, as the specimen in Leske, S. 349.

*3d Family.—Foliated and sparry.—Spars**.
1st variety. *Common Spar.*

Its most usual colour is white or greyish white, also yellowish or reddish white; more rarely olive or leek green, honey or ochre yellow, or flesh or brownish, or purplish red; still more rarely brown, or bluish grey, or greyish black.

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* With us the term *spar*, without addition, always denotes *calcareous spar*.

It occurs both amorphous, cellular, stalactitic, kidneyform, globular, or interspersed through, or pervading in veins, other mineral substances, or investing them, or filling their cavities; or crystallized in various forms; for a minuter description of which we must refer to Mr. Romé de Lisle. The most general are the rhomboidal, but frequently we find them crystallized in hexagonal prisms, terminated by a pyramid often at one end, rarely at both, and sometimes at neither. The angles of the pyramid never correspond with those of the prism, which distinguishes them from quartzy crystals: the pyramids sometimes resemble the head of a nail. Very frequently spars occur in the form of a dog's tooth, often in that of leaves, &c.

Its lustre 3,2, never 0 or 1, but when either decomposing or debased by foreign ingredients.

Its transparency 2, 3, 4, 1, if of the amorphous kind 2. 1,5. 1.

Its fracture foliated, generally straight, rarely convex or undulated.

Its fragments generally rhomboidal, or tending thereto.

The amorphous generally presents distinct granular concretions, seldom lamellar or columnar; some seem really striated, as in Leske, O. 1268: the columnar give it a striated appearance, as in Leske, O. 1428.

Its hardness from 5 to 6; specific gravity from 2,693 to 2,718.

By my own experiments, pure semitransparent amorphous spar loses from 43 to 45 per cent. of its weight by solution in acids. Mr. Saussure, junior *, found some rhomboidal spars lose 0,395 by solution in nitrous acid; Mr. Bergman only ,34: it is probable he used the vitriolic acid to dissolve it.

White or grey opaque spars generally contain argill, but certainly not exceeding 12 per cent. for they are all infusible by pure air. The brown ferruginous spars, on the contrary, are all fusible by the heat produced by that air.

Reddish and violet spars generally derive their colour from manganese. 16 Roz. 15 Lasius, Hartz 327.

2nd variety. *Arragon Spar* †.

White or greenish white, and in the middle somewhat blue.

Lustre 2. Transparency 2. 1.

It is found crystallized in hexangular prisms, whose planes are concave.

Fracture sparry; but, as it presents columnar distinct concretions, it appears as if striated.

Hardness 6. Specific gravity 2,778.

Moderately heated, it phosphoresces, emitting a red light, and then falls into powder.

It dissolves slowly, but entirely, in nitrous acid, with effervescence; and contains no fluor acid, as Mr. Klaproth evinced, by dissolving it in vinegar. It probably contains more fixed air than the former variety, and probably a mixture of stronthian.

4th Family.—*See Leske,* O. 1435.—Striated or fibrous. Stalactite, alabaster, sinter.

Its colours are grey, white, yellowish or greenish white, or pale green, or light or cherry red, or reddish brown, or bluish grey, or striped or veined with these colours.

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* 40 Roz. 165.

† Bergm. I. 1788, 91, 96. 3 Berl. Beob. 364. ‡ Chym. An. 1788, 388.

Its form various, amorphous, or branched, jagged, tubular, globular, &c. the surface seldom smooth.

Its lustre 1, but sometimes abounds in shining particles, often 0. Its transparency 2. 1.

Its fracture striated or fibrous, sometimes very faintly, the striæ seldom parallel, oftener diverging as from a common center, or starry; it frequently discovers distinct stratified concretions of different colours, sometimes parallel, often curved or angularly undulating, or concentric.

Its hardness from 5 to 7. Its specific gravity, according to Brisson, from 2,3259 to 2,876; this last undoubtedly from an abundant mixture of metallic or actinolitic particles; but its most usual relative density is from 2,6 to 2,77.

Its effervesces with acids, and burns to lime.

Calcareous sediments and incrustations belong to this family chiefly; that of Carlsbad has its specific gravity from 2,63 to 2,690, and contains but little of iron, silex, or argill.

A fibrous or striated limestone found near the lake Onega, which consists of asbestine or shorlaceous particles, interwoven with the calcareous in the proportion of 1 per cent. the hardness of the former is 9, of the latter from 7 to 8. It also contains 8 per cent. of argill. Act. Petrop. 1782, 270.

Calcareous infiltrations, filling the cavities of other stones, are frequently of this family, and have often been mistaken for zeolytes.

Though most stalactites have a fibrous fracture,

ture; yet there are many whose fracture is earthy.

The fibrous limestone from Poland, Leske, O. 1435, is very remarkable, as it much resembles fibrous gypsum. Its colour is yellowish white. It lustre 2. Transparency 1. Its fracture fibrous, with slender acicular separate concretions standing in different directions. Its hardness 7. Very brittle. Its specific gravity 2,741. It strongly effervesces with acids. Feels harsh.

5th Family.—Swine stone.—Bluish or blackish or yellowish grey, or greyish black, or yellowish or blackish brown, or Isabella yellow.

Lustre 1. 0. Transparency 0. 1.

Fracture various; that of the blackish varieties generally fine splintery passing into the conchoidal; that of the Isabella yellow fine splintery; that of the yellowish grey earthy. All commonly slaty, and discover scattered particles of a foliated texture.

Its hardness from 6 to 7. Specific gravity of a specimen of the grey kind, which I tried, and was penetrated with spar, was 2,701, of that examined by Brisson, 2,7121.

Its most distinguishing characteristic is an urinous or alliaceous smell, which it emits when scraped or pounded.

It is generally presumed to contain some bituminous substance, and with good reason; though I could procure none from the specimen I tried by distillation, nor any air distinct from fixed air; for the whole of the air I procured from it was easily absorbed by lime-water, but of fixed air I found it to contain 0,45.

Swine stone, composed of laminæ, alternately white and yellow, is found in the vicinity of Vesuvius. Gioeni, 13.

Mr. Bergman informs us, that, in the mountains of West Gothland, this stone occurs in great plenty, and is there burned to lime, the expence of fuel being much diminished from the aliment the stone itself affords when heated to redness *. This quality is known in many parts of the county of Galway, where this stone abounds, but fuel is scarce; and hence it is often employed to heat rooms, as it remains red hot many hours.

The browner sorts are I believe most frequently marls or marlites.

7th Family.—Oviform. Erbsenstein.

Their colour is generally yellowish grey, or brown.

Lustre 0. Transparency 0 or 1.

They consist of a number of globules closely compacted together; their hardness from 6 to 7.

3d Species.—Mild calcareous earth, mixed with a notable proportion of other earths, iron, or manganese.

Mixed with barytes or baroselenite. *Baryto-Calcite.*

Of this stone, which I have not seen, Mr. Bergman gives the following account †.

Its colour dark, or light grey, almost white.

Transparency 2.

Form, either that of a wedge, or some segment of a sphere, or rounded, or crystallized in quadrangular prisms.

Fracture striated, and presents separate columnar concretions, more or less diverging as from a common center.

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* 5 Berg. 125.

† 1 Chy. An. 1734, 388.

It contains 92 per cent. of aërated calx, and 8 of aërated barytes.

Specific gravity not given, but I conjecture it to be nearly 2,78.

It effervesces with acids.

4th Species.—Mixed with magnesia. *Muricalcite.*

Of this species, there are two families, neither of which has as yet been accurately described.

1st Family.—In an earthy form.

Of an olive colour. It consists of a large proportion of mild calx, and a smaller of magnesia; and, though it has the appearance of a clay, yet contains no argill. 13 Roz. 60, found near Thionville.

2nd Family.—In a stony form, and amorphous.

A stone of this has been mistaken for the white or sparry iron ore. It is found near Creutzenwauld, and contains 75 per cent. of aërated calx, 12 of magnesia, and 13 of iron; *per Bayen*, 13 Roz. 59. Mr. Chaptal informs us he has detected some proportion of magnesia in many of the limestones of Languedoc, 2 Chapt. 65.

3d Family.—Crystallized.—Compound Spar. Bitter spar of the Germans.

Greyish white, or verging to the dark pearl grey.

It occurs partly shapeless, partly in blunted fragments, partly crystallized in rhomboids, small or middle sized.

The surface of the fragments is longitudinally streaked, that of the crystals rough.

External lustre greasy, 1. internal, pearly 3. Transparency 3.4.

Fracture streight foliated. Fragments rhomboidal.

Presents gross-grained distinct concretions.

Hardness 8, brittle. Specific gravity 2,480.

It does not effervesce with acids until it is pulverized, and then but gently, though completely soluble therein; if previously heated, it will dissolve more quickly. Heated to redness for half an hour, it does not decrepitate, but loses 45 per cent. of its weight. In a porcelain heat, it vitrifies with the crucible, which it transpierces. By Mr. Klaproth's analysis, it contains 52 per cent. of mild calx, 45 of mild magnesia, and 3 of iron mixed with manganese. 5. Berl. Beobacht. 55.

It is found in Tyrol, and generally mixed with chlorite and talc.

5th Species.—Mixed with a notable proportion of argill or clay. *Argillo-calcites.*

1st Class.—Readily disintegrable by exposure to the atmosphere.

Marls, or Calcareous Marls *.

1st Family.—In an earthy or semi-indurated form. *Mergel erde* of Werner.

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* Though there are different distinctions of marls, yet by the term *marl,* without farther addition, calcareous marls are understood.

Generally yellowish grey, more rarely yellowish white.

Lustre 0. Transparency 0.

Surface dusty.

Slightly compacted together, frequently loose.

Feels dry and rough. Specific gravity from 1,600 to 2,4.

It strongly effervesces with acids, and, when dissolved therein, the residuum, dried in a heat of 100° Fahr. weighs from two-thirds to four-fifths of the whole; that is to say, this marl contains from 30 to 80 per cent. of calx.

It is fusible in a heat of from 130° to 140° of Wedgwood.

In water it soon falls into powder, and is not ductile; the compacted part farther moulders by exposure to the air.

It consists of mild calcareous earth, in the proportion of from 66 to 80 per cent. the remainder clay, with which mica, and other foreign ingredients, and frequently shells, are mixed. But clay itself contains two ingredients, namely, argill and silex; and hence this family divides into two branches; the one in which the argill exceeds, or at least amounts to 20 per cent. of the whole residuum; the other, in which the siliceous ingredient amounts to more than 80 per cent. of the whole residuum. This distinction, which is of some importance in agriculture, cannot be directly made by means of a chemical analysis; however, it may be inferred from the property which the residuum, after solution, has or has not of making a good brick; if it cannot be formed into a brick, then the siliceous ingredient exceeds; if it can be made into a brick, and this brick is liable to crack in drying, then the argillaceous ingredient exceeds.

2nd Family.—In a stony or indurated state. *Verharteter Mergel* of Werner.

Yellowish white, or yellowish or bluish grey, or Isabella yellow or brown, or reddish, or yellowish brown, or brick red, or flesh coloured, or greyish black.

Surface often dusty.

Lustre 0. Transparency 0.

Fracture earthy, sometimes inclining to the splintery, or concheidal, frequently slaty.

Hardness from 5 to 7. Specific gravity (when it can be taken) from 2,3 to 2,7.

It is fusible by a heat of 133° into a dark green compact glass.

Most frequently crumbles soon after immersion in water.

It effervesces strongly with acids, and by solution therein loses from 0,25 to 0,32 of its weight.

The residuum, after solution, being well washed and dried, weighs from two-thirds to one-fifth of the whole.

It consists of mild calx and clay in the same proportion as the former variety, and frequently a large proportion of marine shells. Most marls contain a small proportion of magnesia, and some vestiges of marine acid *; they are liable also to various other contaminations.

By exposure to the air and moisture, it sooner or later, generally at farthest within a year, chips and falls to pieces. This disintegration is remarkable, for it does not proceed solely from the absorption of water, and the dilatation and contraction of this absorbed water, by the varying temperature of the atmosphere, as it takes place in climates under which this variation is not considerable; nor does it proceed from the absorption of air by *ferruginous* particles it may contain; for marls that contain scarcely any iron, or which contain iron in a state that admits of no farther calcination, equally fall to pieces after exposure to the atmosphere, and so do the shells contained in it. I suspect it to proceed partly from the absorption of moisture, and partly from the absorption of air by the carbonic principle of the marine exuviæ, or shells found in the marl.

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* Per Monnet, 4 Roz. 180.

Marls that contain only 66 per cent. of mild calx are frequently burned to obtain lime; this lime takes less sand indeed, but is unfit for constructions under water. Dr. Withering remarked, that marls, which contain above one-fourth of their weight of aërated calx, will not form bricks. Dr. Higgins observed that mortar, which contained one-eighth of its weight of argill, was subject to chip by exposure to the air and moisture. *On Cements*, 121.

It has, however, been observed by Mr. Maquer, that limestones, which contain only 0,15 or 0,16 of argill, possess all the properties of limestones; Mem. Par. 1728: yet this must be restrained to the case in which they are not exposed to an high degree of heat, or he must mean *pure argill;* for, if they contained that portion of *clay*, they would undoubtedly be fusible.

This *family*, like the foregoing, is divisible into two branches; the one, in which the argillaceous part of the clay exceeds the siliceous; the other, in which the siliceous is to the argillaceous in a higher proportion than 4 to 1.

1st Branch.—Of this sort, I do not recollect that any have as yet been analysed.

2nd Branch.—*Siliciferous Marls.*—These, as before said, possess the same characters as the foregoing, except that they do not harden when calcined; nor does the residuum, after solution in acids, form a brick. These properties, it must be understood, are susceptible of various gradations, as the compositions necessarily vary from each other. Of this sort, a few are mentioned by Dr. Withering, Phil. Trans. 1773.

1. *A brownish white marl,* resembling a calcareous incrustation. It contains 53 per cent. aërated calx; the remainder sand.

2. *A lead-coloured friable flaky marl,* contained 48 per cent. aërated calx; remainder sand.

3. *A brownish-grey marl,* very hard, in irregular lumps; contained 53 per cent. aërated calx; the remainder sand.

4. *A lead-coloured marl,* in powder or small hard lumps; it contained 66 per cent. aërated calx, with sand, and a small proportion of argill.

2nd Class.—Not readily disintegrable by exposure to the atmosphere.

Marlites.—Light or dark grey, or bluish or yellowish grey, or brownish red, or flesh coloured, or greyish black.

Lustre 0, transparency 0, when the limestone is of the compact kind; but, when it is of the granular, some lustre and transparency are perceived, as in the specimen, Leske, 564.

Fracture most earthy or conchoidal, seldom splintery, frequently slaty, more rarely granularly foliated, sometimes mixed.

Hardness from 4 to 8. Specific gravity from 2,3 to 2,877.

Effervesce with acids, though sometimes slowly.

They are not disintegrated by exposure to the atmosphere, at least in six years. Hence we see they differ but little from marls in their external characters; however, the property of resisting the influences of the atmosphere, at least for a considerable time, is too important a ground of distinction to be passed over.

1st *Family*.—In this, next after the calcareous ingredient, the argillaceous predominates.

Argilliferous Marlites.—1. A dark blue limestone, of a conchoidal or semilenticular form, opaque, dull and slaty, hard as 8. Specific gravity 2,877 It contained 0,50 of mild calcareous earth, 32 argill, 12 silex, and 2 of iron.

2. Orbicular masses (geods), containing brown or bluish grey marl, split in compartments, and intersected with veins of spar, called *Ludi Helmontii*. I cannot, however, say that I particularly examined these.

3. *Mollasse*, a grey or yellowish grey stone, found in the neighbourhood of Lausanne, and various parts of France, at least those parts of it that, after a length of time, are injured by exposure to the air, seem to belong to this family.

4. Various stalactites, such as those consisting of hollow cones, including others of the

same sort found in Hælsingburgh, and which, according to Baron Born, are difficultly soluble in nitrous acid, and when calcined, and thrown into water, deposit a considerable proportion of argill. 1 Raab. 304.

5. Various red and green marbles, such as the brownish red marble of Ingermania, variegated with red and green. Its fracture earthy. Its hardness from 6 to 7. It abounds in petrifactions, effervesces weakly with acids, by calcination becomes grey, and affords a bad lime. By Mr. *Georgi's* analysis, it contains 65 per cent. of aërated calx, 17 of argill, 12 silex, 3,5 of salited calx, and 2 of iron, Act. Petrop. 1782, 276. It entirely resembles that of Robeck in Kinneculla, which Mr. Bergman tells us is fusible in a strong heat, and yet affords a weak lime, Mem. Stockh. 1768; and the green Campan of the Pyrenees, which, by Mr. Bayen's analysis, consists of 0,65 aërated calx, 0,32 argill, and 0,03 of iron slightly calcined.

6. Some bluish and yellowish grey limestones of a compact texture, such as that found in the bishoprick of Fulda, which contains 75 per cent. of mild calx, and 25 of argill. Voight *Fulda*, 15.

7. Various porous limestones, which afford a very poor lime, are probably of this family.

8. Mr. Ferber, in Nov. Act. Petrop. 1785, p. 263, mentions a very singular fossil, a marl crystallized in an octohedral form, like alum, which contains argill and silex; but nothing farther concerning it is as yet known.

2nd Family.—In which, next to calx, silex predominates.

Siliciferous Marlites.—Of this there are many varieties, several of which give fire with steel at the same time that they effervesce with acids.

1. A brownish red and white marble of Finland, of micaceous or scaly texture, whose hardness is 9. It contains 74½ per cent. aërated calx, 16 silex, 5 argill, 3 magnesia, and 1 of iron. Per *Georgi Act. Petrop.* 1782, 276.

2. A greyish blue marble from Pergula, near the lake Onega, of a minute scaly texture, yet somewhat angular in its fracture. Its hardness from 8 to 9. It contains 79 per cent. aërated calx, 18 silex, 2,5 argill, and 0,5 iron. *Ibid.*

3. A greyish black marble spotted with white, from Sardopol, on the lake Onega, of a minute scaly texture, with a few micaceous particles. Its hardness from 7 to 8. Contains 66 per cent. of aërated calx, 19 silex, 10 mica, 4 argill, and 1 of iron. *Ibid.*

4. A flesh coloured marble, variegated with white, also from the lake Onega. Its hardness 9. Contains 75 per cent. aërated calx, 16 silex, 5 argill, 2 mica, and 2 of iron. *Ibid.*

5. A blackish calcareous slate, found near Courmayer, in the Alps, is fusible, and contains 0,615 calx, 0,275 silex, 0,06 magnesia, 0,0225 argill, and 0,015 iron. 2 Sauss. 298.

6. A blackish limestone, found in Tauria, exactly resembling a flint mentioned by Prince Gallitzin in his description of that country, 1 Bergbau, 298; and another resembling horn stone found at Furstenberg, which with limestone contains a quantity of sand; of which Langer makes mention in his mineral history of Paderborn, p. 8; and the slaty limestones found on the Grampians in Scotland, which effervesce

with acids, and give fire with steel, 1 Bergb. 399, are of this family.

7. Silicicalcareous freestones, which are often porous, and serve for filtering stones, such as *Pierre de Liais,* which, according to Monnet's Mineralogy, 12, contains 33 per cent. silex. Its specific gravity, according to Brisson, is from 2,07 to 2,4.

8. Arenaceous limestone, such as that found at Sharzfeld in the Hartz, Lasius, 193. Its specific gravity 2,489.

9. A radiated stelliform limestone (Sternspath) found on the Carpathian mountains by Mr. Fichtel. Its colour white and greenish. Lustre silky. According to Mr. Bindheim, it contains 0,66 per cent. mild calx, 0,30 silex, and 0,03 iron; but he tells us it is fusible by the blow pipe, which could not happen if it did not contain argill also, or the siliceous stone must have been of the fusible kind, and even so it would scarcely be fusible.

10. Mr. Chaptal informs us, that some limestones in Languedoc contain so much silex, that when calcined they need only be beaten up with water to make good mortar. 2 Chapt. 34.

3d Class.—Argillocalcites, penetrated with bitumen, sulphur, or pyrites.

1*st Family.*—*Bituminous Marlite.* Bituminoser Mergel Schiefer of Werner.

Colour greyish or brownish black. Fracture partly straight, partly curved, or undulatingly slaty; the internal surfaces of the former rough, of the latter smooth. The laminæ either thick or thin. Fragments tabular.

Lustre of the straight slaty 0, of the curved slaty 1.2. Transparency 0.

Hardness 5. Specific gravity from 2,361 to 2,442.

Feels dry. Often contains copper pyrites.

It effervesces with acids, even the specimens that have most the appearance of coal, as those in Leske, O. 1538, 1535. The specimen 1537 effervesces but weakly.

It most commonly bears impressions of fish or marine plants.

It seems to be the shale bind of 4th Watson, 344, yet its specific gravity, according to him, is 2,681.

This stone must not be confounded with bituminous shale (brand schiefer), which it much resembles; *that* is an argillite, scarcely effervesces with acids; *this*, a calcareous stone, strongly effervesces with acids: its specific gravity at a medium 2,388.

The former is found in coal-mines, the latter is not attached to them, but often contains copper ore.

2nd Family.—Pyritaceous Limestone.—Dark grey, or yellowish grey. Lustre 1, from some interposed shining particles.

Transparency 0. Fracture compact, often slaty. Hardness from 8 to 9, brittle. Specific gravity 2,703.

Gives a grey powder, is not magnetic.

Soluble in acids, and sometimes with effervescence.

Detonates with nitre.

Calcined with charcoal affords a liver of sulphur.

Distilled, it affords some flowers of sulphur, and volatile vitriolic acid.

By the analysis of Baron Servieres, it contains 75 per cent. mild calx, and 25 of pyrites, consisting of 14 parts argill, 7 quartz and sulphur, and 4 of iron*.

6th Species.—Argentine. Schiefer spath of Werner.

Colour greyish, reddish, or greenish white.

Lustre, where fresh broken, and in the direction of the lamellæ, 3,2, and of the silvery kind, as I think; some call it intermediate between that of wax and mother of pearl.

Transparency 1.0 1.5.

Fracture curved foliated, in the gross slaty. Fragments 2.

Hardness 5 to 6. Very brittle. Specific gravity 2,647. Hath somewhat of a greasy feel. Effervesces strongly with acids.

Heated to redness, it turns reddish brown; by a heat of 155° it is converted partly into a brown porcelain mass, and partly into a reddish brown glass, which attacks the crucible.

Its composition is not yet known, and I had too little of it to allow a farther examination; but from its action on the crucible, I think it probably contains magnesia, and a small proportion of argill and calx of iron.

According to Mr. Kärsten, its specific gravity is intermediate between the heavy and not remarkably heavy. Leske's Catalogue, p. 273. Mr. Hoffman, however, did not find its specific gravity so high. That which I examined was taken from the specimen in Leske, O. 1499.

It has hitherto been found only in Barman's Grün, near Schwartzenberg, and Konsberg, in Saxony, and in the Shara pit, in Norway. The silvery chalk, already mentioned, seems however nearly related to it.

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* 21 Rozier. 394, 22 Roz. 207.

7th Species.—Combined with manganese and iron*.

Sidero Calcite. Braun spath of Werner, spath perlé of Romé de Lisle.

Colour white or greyish, yellowish or reddish white; the red sometimes rises to the rosy, sometimes sinks to the brown or darker red; the yellow degenerates often into Isabella or brownish black. Sometimes many of these colours occur together, and frequently present an iridescent or tarnished metallic appearance.

It is found amorphous, cellular, rounded, but more generally crystallized.

Its external lustre (when not much decomposed) is metallic or pearly, 3.2; its internal, glassy, 2 or 1. Transparency of the crystallized 2.1.0, of the others, 0.

When crystallized, its forms are various: 1, lenticular; 2, rhomboidal, with plane or convex faces; 3, pyramidal and solid, with convex faces, or pyramidal and hollow, all small and low.

Fracture partly straight, partly curved foliated; the fragments of the former tend to the rhomboidal form; of those of the curved foliated, indeterminate.

Hardness 8, brittle. Specific gravity, 2,837, per Brisson; yet that of the specimen, Leske, O. 1504, had its specific gravity only 2,396. It consists of a group of yellowish pyramidal crystals seated on a porous incrustation, probably of the same substance; that examined by Mr. Brisson was a solid rhomboid.

It effervesces with acids, sometimes briskly, sometimes very slowly *; if the stone be white, the nitrous acid leaves on it a yellow stain.

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* Karsten in Leske, p. 275. 1 Bergm. I. 1789, 190. 12 An. Chy. 165.

It frequently occurs decomposed by exposure to the atmosphere.

When heated, it decrepitates, and becomes red or brown, and often magnetic. In a strong heat, the white transparent crystals lose about 0,455 of their weight; 0,40 being fixed air, and 0,05 water. 40 Roz. 163. For the amorphous see the specimen Leske, S. 178 and 772.

It consists of variable proportions of aërated calx, aërated manganese, and iron.

This stone hath been so long mistaken by myself and others, that a history of the opinions concerning it may be somewhat interesting.

Romé de Lisle is the first who has given any thing like a description of it in the first edition of his Crystalography, A. D. 1772. He there tells us it consists of a number of crystals, or rather rudiments of crystals heaped on each other, of a silvery white or golden hue, and calls it *pearly spar;* but he totally mistook its nature, for he reckoned it among the fluor spars, p. 155.

In the year 1778, Mr. Woulfe read a paper before the Royal Society of London, printed in the Transactions of 1779, in which he gives a much fuller account of this stone, which he considers as a *non-descript*. It forms, he tells us, flat rhomboidal crystals, and discovers great variety of colours, being found either white and semi-transparent, or pearl coloured, or reddish, or of different shades of brown or yellow; some of the lustre of gold, brass, or copper.

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* Bergm. I. 1789, 189. 7 Roz. 224, 226. Phil. Trans. 1779, 29. That of Leske, O. 1504, effervesces briskly, though not so strongly as calcareous spar.

Its hardness only inferior to quartz or felspar, and effervescing with the three mineral acids. He then proceeds to its analysis, which, making allowance for the time (manganese being then in a great measure unknown), has undoubtedly great merit. He distinctly proved the existence of calcareous earth, of magnesia, or some new substance with which the vitriolic acid afforded white rhomboidal crystals of a styptic bitter taste, and iron; whence he concluded that 180 grains of this spar contains 109 of mild calx, 63 of *magnesia* or some new earth, and 8 of iron; or 100 parts of the spar contain 60,5 mild calx, 35 of this new earth, and 4,4 of iron.

By this account, I was led to think this spar contained magnesia as well as calcareous earth, and hence, in my *former Elements*, I called it *compound spar*.

In the mean time, Mr. Romé de Lisle, in the second edition of his Crystalography, made a nearer approach to the true nature of this stone, though he still mistook it. He tells us, p. 616, 619, 622, that it frequently passes into the sparry iron ore. This observation at once opened to me its true composition, for, the agreement of his decomposition with that of Mr. Woulfe persuaded me that his *spâth perlé* was that new spar described and analyzed by Mr. Woulfe, who indeed suspected some connection between it and the sparry iron ore, though a fallacious experiment afterwards induced him to deny that this ore contained calcareous earth; but the experiments of Mr. Bayen and Mr. Bergman prove that point beyond contradiction.

Lately Baron Born, in the catalogue of the fossils of Miss Raab, though well aware that the spath perlé of Romé de Lisle was the same as the *braun spath* of the Germans, and that this latter contains manganese as well as mild calx, was nevertheless persuaded that the stone analyzed by Mr. Woulfe was totally of a different nature, and that it really was composed of mild calx and magnesia. To this mistake I was, I must own, in a great measure accessary, as I did not mention that Mr. Woulfe himself suspected that what he called magnesia was not true magnesia, but a new earth. A stone, however, of the same nature as that which I had wrongfully ascribed to what I called *compound spar,* Baron Born asserts, has been found in the valley of Zillerthal in Tyrol, in a steatitic rock; the description he gives of it exactly corresponds with that of Mr. Woulfe, except that it neither effervesces nor dissolves in acids, both which Mr. Woulfe expressly says the stone described by him does; the Baron, therefore, in all probability was deceived.

1. From what has been said, it may be inferred that *braun spar,* or sidero-calcite, exhibits in its composition various gradations to or from the sparry iron ore; like this it sometimes effervesces with acids, and sometimes this effervescence is scarcely perceptible. *Bayen Mem. Etrang.* 9, 704. 2 *Bergm.* 198. 2. The proportion of calcareous earth varies considerably in this ore, so that sometimes it contains no more than 2 or three per cent.; and hence it escaped the action of tartar vitriolate in Mr. Woulfe's experiment; for, if selenite were formed, yet a few grains of it would remain dissolved, and afford no precipitate. 3. This ore contains manganese, and it is this which, with the vitriolic acid, formed white bitter

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rhomboidal crystals in Mr. Woulfe's experiment; to this the fatiscence, or efflorescence, or decomposition, of the sidero-calcite is owing. 4. The varying density of this stone is also an evident consequence of its varying composition as well as texture.

8th Species.—Mixed with a notable proportion of iron.

Ferricalcites.—Reddish, yellowish white, or brownish yellow, or brownish red, or dark or yellowish brown, or brownish blue.

Lustre 0, 1. Transparency 0. Fracture generally slaty, often granularly foliated.

Hardness from 7 to 8. Specific gravity from 2,8 to 2,9.

Moulder by exposure to the atmosphere. Effervesce with acids.

They contain from 7 to 14 per cent. iron, and most frequently a proportion of clay; but, after the calx, iron is the characterizing ingredient; some, however, only contain so much as to render them capable of decay. These are rifty, and present numerous distinct concretions. See the specimen in Leske,' S. 530, &c.

1. A brown foliated limestone, found near Rabenstein in the Hartz; it is fusible per se, and consequently contains clay. Its specific gravisy 2,848. *Lasius* 192.

2. A brown iron-shot limestone, consisting of entrochites cemented together by a ferruginous cement. Its specific gravity 2,882. *Ibid.*

3. A bluish limestone of a slaty structure, which acquires a rusty colour by exposure to the air, and is fusible by the blow-pipe. 2 *Sauss.* 187.

4. A yellowish white limestone, of a granu-

lar or foliated texture, which becomes brown by exposure to air. By calcination, it loses from 20 to 50 per cent. of its weight. It contains about 10 per cent. of iron and manganese. Found at Hællefors in Sweden. *Schwed. Abhand.* 1754, 291.

5. A red limestone, found also at Hællefors, contains 10 per cent. iron. Rinm. § 189.

6. A pale red or yellow limestone, found at Ryttershutten in Sweden. Its hardness 9. Specific gravity 4,988. Does not effervesce with acids; becomes magnetic after roasting; and contains, according to Messrs. Elyart, about 54 per cent. pure calx, 24 iron, and 22 silex. *Schwed. Abhand.* 1784, 121.

7. Greyish red compact limestones of a porous texture, almost passing into sand stones, void of lustre and transparency, with an earthy fracture, and resembling mortar, as in Leske, S. 132. See also *Derivatives.*

9th Species.—Supersaturated with fixed air, and frequently phosphorescent.

Dolomite.—1*st Family.*—*Common Dolomite.* Dolomie of Saussure *.

Pure or greyish white, or yellowish white, or light red.

Lustre 0, 1. Transparency 1. Fracture conchoidal or granularly foliated.

Hardness from 8 to 9. Specific gravity from 2,85 to 2,862.

It effervesces slowly with acids unless pulverized.

Does not wither by exposure to the atmosphere.

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* 40 Roz. 162.

sphere. Phosphoresces by collision either against another, or on being scraped by a knife; but this property is not found in all of them. Duly calcined, it loses 0,46 or 0,47 of its weight, and is converted into lime *. By the analysis of Mr. Saussure, the younger, 100 parts of it contain 44,29 of calx, 5,86 argill, 1,4 magnesia, 0,074 iron, and 46,1 of fixed air.

Hence we see that the lime in this stone is united to a much greater proportion of fixed air than in other limestones; 100 parts lime in Carrara marble take up 86 of fixed air, but in this stone 100 parts lime take up above 100 parts of fixed air. Does not this proceed from its containing an excess of the carbonic principle?

Mr. Dolomieu has the merit of having first drawn the attention of mineralogists to this sort of limestones. Hence Mr. Saussure, junior, has distinguished it by the name of this justly-celebrated Geologist. His analysis is replete with many new and important observations.

In 1 Bergm. I. for 1792, p. 218, we find also a yellowish spar mentioned, whose form is tabular and expanded, consisting partly of granular and partly lamellar distinct concretions, which effervesce very slowly with acids. See also *Voight*, Mineralogisch. Abhandl. 54.

2nd Variety.—Elastic Marble †.—Colour somewhat yellowish white. Surface rough and uneven.

Lustre 1. Transparency 1. Fracture verging from the compact to the granularly foliated.

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* Roz. 39, 5.

† 41 Roz. 86, by Mr. Fleuriau de Belvue.

Hardness from 6 to 7, brittle. Specific gravity 2,836.

When its length exceeds 10 or 12 times its thickness, it is slightly flexible and very perceptibly elastic.

It phosphoresces when struck in the dark, or when laid on red hot iron.

It absorbs about $\frac{1}{100}$ of its weight of water heated to 70° in three quarters of an hour; specific gravity is then 2,850.

It effervesces and dissolves in acids still more slowly than the former variety.

By the analysis of Mr. Saussure, junior, it contains 0,322 of calx, 0,175 argill and iron, 0,03 mica, 0,0035 magnesia, and 0,4638 fixed air. Note, the iron scarcely exceeds $\frac{1}{100}$ of the whole. Here also we find the pure calcareous part highly supersaturated with fixed air; for, as 32,2: 46,38 :: 100: 144.+

It was first observed in the Borghese palace at Rome, and lately on Mount Gothard in Switzerland.

Observations.—Any stone of a fine grain, considerable hardness, and which admits of a good polish, is in general called marble; but this denomination is now mostly confined to aërated limestones.

White marbles, and transparent spars, are reckoned the purest of the aërated species, and among the former that of Paros and Carrara; but this last we have seen to contain a slight proportion of argill and mountain crystal; and some parts of its immense beds, I am informed, are remarkably replete with siliceous particles. Exposed to a heat of 700° Fahr. for several hours, it loses but $\frac{1}{1000}$ of its weight, therefore contains scarcely any water. 41 Roz. 96.

The white marble of Stannovai, near Catharinenburg in Siberia, contains, according to Mr. Georgi, 93 per cent. of mild calx, 6 of silex, and 1 of argill. It is the same as that brought to Paris by Abbé de la Chappe. Specific gravity 2,7185, per Brisson. Abbé Poda is said to have discovered it in a portion of aërated barytes. 1 Raab, 287.

Black marble frequently contains iron; in that used in Paris, Mr. Bayen detected 5 per cent. of iron; but it derives its colour from bitumen most probably, for it affords a white lime, 11 Roz, 496. The specific gravity of fine Italian marble is 2,712.

The Chinese sounding stone, called Hion Chè, or Calcophonos of Pliny, is of this species. The Duke de Chaulnes has shewn it to consist of calcareous earth, with bitumen and iron. It has much the appearance of basalt, 6 Mem. Chin. Thorough black marble is very scarce. Some black marbles will not melt even by the aid of pure air, others will. Ehrm. § 210.

Grey marbles, or limestones, appear to be the lighest. I found the specific gravity of a grey marble from Saxony only 2,700. It contained 42 per cent. of an ill smelling fixed air.

Pale red limestones, I believe, are mostly dolomites. One from Tiwdi in Finland afforded Mr. Georgi 96 per cent. of mild calx, 1 of silex, 1 of argill, and 1 of iron. It gave fire with steel, effervesced with acids very slowly, and presented a fracture like quartz. 1 Act Petrop. 1782, 276.

Yellow orange marbles are much lighter; the specific gravity of that of Arragon is 2,678, of old Castile 2,691, of that of Loyola 2,709, of that of Lamancha, which seems composed of minute globules, 2,750, of the yellow marble of Sienna 2,677, *Brisson*. It was found by Mr. Georgi to contain 93 per cent. of mild calx, 3 silex, 2 argill, 1 magnesia, and 1 calx of iron.

Green marbles are said to be very scarce: according to Rinman, § 206, they derive their colour from shorl; hence they are generally fusible, Ehrm. § 210. The specific gravity of green campan is 2,741.

Blue, or deep blue, is certainly the rarest colour among marbles; that of Carrara, called Bardiglio, has its specific gravity 2,713. The *dove-coloured* or greyish blue is very common; that of Goroioctschit, in the Ouralian ridge of Catharinenburgh, contains, by Mr. Georgi's account, 86 per cent. mild calx, 4 silex, 3 argill, 6 magnesia, and 1 calx of iron.

Violet marbles or limestones vary much in density; that of the violet marble of Valentia is 2,656, or 2,680; that of Maffra, near Lisbon, 2,723; that of Rome 2,755.

The variegated marble of Florence owes its dentritical figures to manganese. 1 Chy. Ann. 1785, 57.

The marble called *Lumachelli*, found at Bleyberg in Carinthia, owes its splendour to shells agglutinated by a grey or brown calcareous matter with argill and iron.

Besides the characters arising from texture and colour, there are other distinctions arising from composition, which are of considerable importance for œconomical purposes; for instance, the distinction of fat and meagre limestones, as the workmen call them.

The *fat*, or those which being converted into lime take up the greatest quantity of sand, are much esteemed by mercenary architects, as sand is the cheapest ingredient.

Meagre lime takes up less sand, yet forms a harder mortar even in water. Mr. Smeaton remarked, that all stones which afford a buff-coloured lime are of this sort. Eddystone, § 171. So also are those that afford a dark or blackish lime, according to Mr. Bergman, who first discovered that this property proceeded from the manganese contained in the lime, 2 Berg. 229. It is however said, that a certain proportion of silex and iron pre-existing in the stone, contributes not a little to this property, 2 Sauss. 115, 140; and much I believe depends on the state in which the iron exists in it, as shall be seen in treating of Pouzzolana Of the stones in which this property has been principally noticed, authors have given but a very imperfect description. I must, therefore, repeat it in their own words.

1. The *Stone of Lena* in Upland, mentioned by Mr. Bergman, is grey, mixed with greenish white particles, and very hard; generally invested with the brown calx of manganese. It loses 0,39 of its weight by calcination, and affords a brown lime. I believe all limestones invested with a brown crust are capable of producing the same effect. The presence of manganese is discovered by melting these stones with double their weight of nitre; the manganese, if any there be, will leave a green trace on the sides of the crucible.

2. A dark grey, compact, and exceeding hard stone, from Brion in Burgundy, presenting in its fissures some brown friable matter. It loses

0,39 of its weight by calcination. 2 Mem. Dijon, 1783, 93.

3. *A sky-blue stone,* with shining particles, found at Aberthaw, in Glamorganshire, gives a buff-coloured lime, and contains about 12 per cent. of a bluish clay, which reddens when calcined.

Meagre lime is reckoned the worst for manure.

All limestones, as we have seen, contain fixed air. Fixed air is now known to consist of pure air and charcoal, the carbonaceous principle, most probably in the proportion of 72 of the former to 28 of the latter; but limestones are as ancient as the creation; therefore since they always contained fixed air, charcoal must also have been an original principle, and being so, it most probably enters into many compositions in which it has not been hitherto suspected. Over and above that, combined with pure air, it certainly exists in shells with which compact limestones abound, and I believe in all limestones of the darker colours. It is certain that all these stones emit a bituminous smell by friction, and many of them contain other traces of bitumen; now bitumen essentially contains the carbonaceous principle; hence we see that lime, formed in close vessels, is never perfectly white, for the coaly principle remains unconsumed, that is, uncombined with pure air, with which in close vessels it cannot come in contact. Is it not from coal thus existing in lime that the mephitic air proceeds, which Dr. Priestley observed to succeed the production of fixed air? for charcoal is known to absorb and retain mephitic air. 6. Pr. 226. Hence also Dr. Higgins found that one-thirty-eighth part of the air yielded by limestones is mephitic air. *On Cements,* 8.

10th Species.—Combined with the vitriolic acid.

Gypsum. Selenite.—It is soluble in the temperature of 60° in about 500 times its weight of water; but to effect this solution in a moderate space of time, it is requisite that the gypsum be presented in the state of fine powder, otherwise it will be very slowly effected; but in boiling water much more of it may be dissolved, which will precipitate on cooling, so that no more than $\frac{1}{500}$ or $\frac{1}{450}$ will remain in solution. The calcareous earth is precipitable therefrom by caustic fixed alkalis, but not by the caustic volatile; and the filtered solution affords tartar vitriolate, or Glauber's salt.

When pure, it does not effervesce with any acid, and is scarcely soluble in any of them, except the concentrated vitriolic, which, when heated, and particularly when boiling, takes a large proportion of it*. Per Morveau, 18 Roz. 302.

Artificial gypsum, so far dried as to retain its glassy appearance, contains 34 per cent. of mere calx, 48 of the strongest vitriolic acid, and 18 of water. Mr. Lavoisier found 9 parts natural gypsum, to afford by distillation 2 of water†, which agrees very nearly with my determination of that contained in the artificial: but some sorts of gypsum contain a mixture of mild calx, which is foreign to their constitution, and therefore effervesce with acids. This sort of gypsum seems to have been formed by precipitation from some other acids, and its proportion of ingredients is different from that found in the former, as I have elsewhere shewn. Most gypsums also contain about 2 per cent. of iron, and several, more; besides a small proportion of silex and argill.

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* Yet Beaumé says, that dilute vitriolic acid dissolves $\frac{1}{18}$ of its weight of gypsum, 1 Beaumé, 273; and that dilute nitrous acid, and marine acid also, and vinegar dissolve it as water.

† Mem. Scav. Etrang.

The easiest method of decomposing gypsum is to boil it in a solution of milk alkali.

In a clay crucible gypsum melts at about 130° Wedgwood, but it is infusible on coal or in chalk crucibles. By a blow-pipe it may be reduced to a globular form, if the blue flame plays on the edges of the lamellæ, because the acid is then converted into sulphur. Macquer found the purest gypsum invitrifiable by solar heat; that of Monmartre seemed to yield, but probably was not pure. Even the heat excited by pure air, if continued long enough to dissipate the acid, cannot vitrify it; and as the experiments on its fusion, by Mr. Lavöisier and Ehrman, were made on gypsum lying on charcoal, it is probable its fusibility even then proceeded from the conversion of the acid into sulphur; yet Geier asserts it is fusible by pure air when held in a tongs.

When powdered and heated a little below ignition, it undergoes a motion similar to that of ebullition from the eruption of the water of crystallization; if taken up as soon as this motion ceases, and then sprinkled over with water, it soon concretes and hardens by re-assuming and crystallizing with the water it had lost.

Its hardness is from 4 to 5, and its specific gravity according to Brisson, from 2,167 to 2,311; if higher, it is impure: but he seems not to have seen a lighter sort, which is called alabaster, whose specific gravity by the trials of the Philosophical Society of Oxford, and of Mr. Ward, is 1,872. Mr. Brisson applies the term alabaster only to certain calcareous spars, following Mr. D'Aubanton, in Mem. Par. 1754.

Of this species I distinguish 4 families: the Farinaceous; the Compact; the Fibrous, or striated; and the Foliated.

1st Family.—Farinaceous Gypsum.—White. Lustre 0. Transparency 0. Of the consistence of meal. Will not form an adhesive concretion, as hair-powder does, without being wetted. Feels dry and meagre. Is not gritty between the teeth. Scarcely sinks in water, and, when it does, becomes slimy. Slightly effervesces, but is scarcely dissolved by nitrous acid. When heated a little below redness, becomes of a dazzling white. Lazius, 238.

2nd Family.—Compact Gypsum.—Dichter Gypstein of Werner. Alabaster.

Greyish or yellowish white, or yellowish grey, or bluish grey, or greenish grey, or olive green, or wine or honey yellow, or light or dark red. These colours often meet in the same specimen in spots, stripes, or veins; brown spots also often occur.

Lustre 1 or 0. Transparency 2, 1, 0.

Fracture compact, mostly splintery, sometimes passing into the fine-grained foliated. Fragments 1 or 0. Hardness 4. Specific gravity from 1,872 to 2,288. Feels dry, but not harsh. Does not decrepitate when heated. Often effervesces, though slightly, with acids, probably from a mixture of aërated calx.

Mr. Nadault found 3lb. of gypsum to contain 36 grains of nitre, beside common salt, 3 Buffon, Minéralogie, 8vo. p. 70.; but this is merely casual.

The specimen, Leske, O. 1547, is white; its specific gravity 2,347: but the specimen, O. 1548, effervesces smartly, though for a short time: its specific gravity is 2,315. Hence we see that the mixture of unsaturated calx renders it heavier.

The specimen, Leske, O. 1551, is hard as 6 or 7. Specific gravity 2,939. It is said that it is intimately mixed with swine-stone; but this does not explain the reason of its remarkable density; perhaps it contains stronthian instead of, or with, common calx; but as it does not effervesce with acids, this is also doubtful.

3d Family.—Fibrous, or striated.—White, or greyish, yellowish, or reddish white, often grey or flesh red, or honey yellow. Sometimes these colours meet in stripes.

Lustre 2, 3. Transparency 2, 1, 3. Fracture fine or coarse, fibrous or striated, the fibres, &c. generally straight and parallel, yet sometimes bent. Fragments long splintery 1. Hardness 4, brittle. Specific gravity 2,300

Does not decrepitate when heated; never effervesces with acids; when polished, becomes iridescent. 1 Raab, 346.

The specimen in Leske, O. 966, is much harder; it does not yield to the nail.

4th Family.—Foliated.—Of this there are two varieties, the small-grained and sparry, and the broad foliated.

1*st Variety.—Granularly Foliated.*—Blattriger gypstein of Werner.

Greyish or yellowish white, or yellowish, bluish, or greenish blackish grey, or light or dark flesh red; or brown, or olive green.

Lustre 2, 3. Transparency 2, 3. Fracture foliated, straight, but mostly somewhat curved. Fragments 0, 1. Presents fine and coarse grained, often straight or curved distinct concretions. The fine-grained easily crumble and separate like sand stones.

Hardness 4,3. Specific gravity from 2,274 to 2,310. Feels soft.

This and the compact are frequently mixed, and pass into each other, and (though rarely) the fibrous and foliated meet and intersect each other at right angles.

The specimen, Leske, O. 1552, varies much from this description, for its hardness is from 6 to 7, its fragments 3, and its specific gravity 2,900. It effervesces briskly with acids. Its fracture partly fine splintery, and partly foliated. It is evidently impure, though its colour is nearly pure white.

Many stones of this family may easily be mistaken for limestones, without much attention. See the specimen in Leske, S. 620, 621.

2nd Variety.—*Broad Foliated.*—Specular gypsum: Fraueneis of Werner. Glacies Mariæ.

Grey, or yellowish grey, sometimes falling into the pale yellow.

It is found amorphous, or crystallized into hexagonal prisms, terminating in an edge, or in rhomboids or cuneiform, tabular, or lenticular

In the crystallized, the planes which form the acute angles are streaked longitudinally, those that form the obtuse are smooth.

Lustre

Lustre glassy, 4, 3, 2. Transparency 4; 3. Fracture straight, or curved foliated.

Hardness 4. Specific gravity 2,311.

It is often penetrated with swine stone (as it is said), which diminishes its transparency, and gives it a disagreeable smell when rubbed. Kärsten on Leske, 293. Maquart 434.

It is found in great plenty, and of an extraordinary size, in Russia, if we may credit Mr. Guetard, Mem. Par. 1762, p. 361, 8vo. and Mr. Maquart, p. 403, both of whom have travelled into that empire: it is there used instead of glass for window panes; nevertheless, Mr. Kärsten assures us this is *absolutely false*.

Gypsum mixed with marl is often found in a slaty form. Of this sort is the specimen, Leske, S. 259. Its colour is bluish grey, and greyish black. Lustre and transparency 0. Fracture slaty. Fragments 3. Hardness 7. Specific gravity 2,473. Heated to redness, it becomes reddish white. As the specific gravity is so low, I presume the gypsum predominates. Sometimes it is mixed with the small foliated, as in Leske, O. 26; the lamellæ are coarse and more imperfect.

11*th Species*.—Combined with the sparry acid.

Fluor.—Fluss of Werner.—This stone is nearly insoluble in water. It does not effervesce with any acid, except the concentrated vitriolic acid, and with that but feebly. The nitrous and marine acids, in the common temperature of the atmosphere, are not absolutely inert with respect to it, but scarcely dissolve it without decomposition. It is insoluble in the acetous.

In a moderate heat, it decrepitates; and if pulverized, phosphoresces, particularly the blue or purple coloured; but, if heated to redness, it will never after phosphoresce. In a heat of 130° of Wedgwood, it melts in clay crucibles, or, but less perfectly, in those of chalk, but on charcoal very imperfectly. By concentrated solar heat, or that given out by pure air, it melts into a button, which is generally white and opaque when cold; if that heat be long continued, it becomes less fusible. Hence, in the heat of our furnaces, it does not part with its acid.

If it be distilled in glass or earthen vessels with the mineral acids, it emits an acid air, which corrodes the vessels, and deposits a siliceous crust on the water in the receiver, which absorbs this air; this is the most certain characteristic of the acid. The vitriolic concentrated, and taken in equal weight with the stone, is the acid most usually employed; a gypsum then remains in the retort.

Hardness from 7 to 8. Specific gravity 3,09 to 3,19.

100 parts of this stone contain about 57 of calx, the remainder acid and water, in a proportion not yet accurately determined, and a small proportion of argill, silex, and iron, with some traces of marine acid, and sometimes of cobalt.

Against the existence of the sparry, as of an acid *sui generis*, many difficulties were started soon after its discovery by some French chemists, disguised under the name of Boulanger, and afterwards by Mr. Achard and Mr. Monnet. To remove these, Mr. Scheele instituted a new series of experiments, which not only impressed the fullest conviction of the object

they

they were meant to illustrate, but once more displayed the unrivalled abilities of the illustrious discoverer, and the infinite resources of his art. Sorry I am to add, that, since the death of this admirable man, a man as eminent in the chemical as Newton in the mathematical branch of natural philosophy, Mr. Monnet has thought proper to renew his attacks in a style of haughtiness and acrimony that inspires infinite disgust: The fallacy of his reasoning is sufficiently exposed by Mr. Leonhardy, in the 6th volume of his late learned edition of Maquer's Dictionary.

Of this species we have 3 families: the *Sandy*; the *Compact*; and the *Foliated*, or *Sparry*.

1*st Family.—In a Sandy or Earthy form.* —This has been found only at Kobola Poiana, in the district of Marmaros, in Hungary. It is of a light grey colour and loose consistence; when strewed on an iron plate heated a little below redness, it diffuses a blue or pale yellow phosphoric light. According to the experiments of Klaproth and Gmelin, it contains the fluor acid singly, and not the phosphoric *. Mr. Pelletier found 100 parts of it to contain 31 of silex, 21 of calx, 15,5 argill, 28,5 sparry acid, 1 of phosphoric acid, and 1 of iron. In an unconnected substance of this sort, different specimens must undoubtedly contain different proportions of ingredients, among these the silex is evidently adventitious, the phosphoric acid being in such small quantity, may be found in some specimens, and not in others. Mr.

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* 1 Chym. Ann. 1787, 52. 1 ditto, 1791, 197.

Hassenfratz discovered vestiges of it in most fluors*.

2nd Family.—Compact.—Whitish grey, and thence passing into the verdigris green. Lustre 1, 2, 0. Transparency 2, 1. Fracture splintery or even. Hardness 8, very brittle. Specific gravity from 3,12 to 3,165.

3d Family.—Foliated, or *Sparry.—Fluor Spar.*—Its colours are very numerous, pure and greenish white, or yellowish or reddish white, or grey or bluish grey, or light or violet blue, or grass, leek, or olive green, or dark red verging to purple, or purple inclining to black, or wine or honey yellow, or yellowish brown. Many of these occur often in spots, blotches, or veins pervading the mass of one and the same specimen.

It is found either amorphous or crystallized. the most usual of the crystallized forms is that of a perfect cube, the angles or edges rarely truncated or bevilled ; these last have sometimes concave planes. The octohædral form is also sometimes met with. See Mr. Romé's descriptions.

Its surface mostly smooth, or frosted over with minute crystals.

Lustre 2, 3. Transparency 2, 3, 4.

Fracture foliated, generally straight, seldom curved ; some parts, however, are found splintery, as if passing into the compact.

Fragments tend to the form of triangular or quadrangular pyramids, present coarse or small grained, seldom prismatic, distinct concretions.

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* 9 Ann. Chy. 225

Hardness 8, very brittle. Specific gravity 3,09 to 3,19; that of the specimen, Leske, O. 1613, is 3,154.

12th *Species.*—Combined with the phosphoric acid.

Phosphorite.—It is nearly insoluble in water. It is attacked by the concentrated vitriolic frequently with some effervescence, but it is rather decomposed than dissolved; and the selenite deposited soon protects the greater part of the phosphorite from the action of this acid.

It is soluble in the nitrous and marine acid, sometimes with scarcely any effervescence.. In the latter it often appears gelatinous. It is insoluble in the acetous. If to a solution in these acids the vitriolic be added, a selenite will precipitate; and, the filtered solution being evaporated, and the selenite deposited during evaporation removed, the liquor, farther evaporated, will assume the consistence of honey; and, being mixed with as much charcoal as gives it the form of a powder, and distilled, a phosphorus will pass.

By a moderate heat or trituration it phosphoresces, but by a stronger heat it loses this property. If reduced to powder it will not decrepitate, which it does when in larger grains. It is scarcely fusible by the blow-pipe, even assisted by alkali, microcosmic salt, or borax.

It contains calx and phosphoric acid nearly in the proportion of 2 to 1. It is commonly contaminated with silex, aërated calx, iron, muriatic selenite, fluor acid, and sometimes manganese *. According to Mr. Hausen, crystallized phosphorite becomes electric by friction with woollen cloth [*].

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* 1 Bergm. I. 1788, 294. 2 Ann. Chym. 94.

Its external characters are as follow:

1*st Family.—Phosphorite. Apatite of Werner.*—Colour grey, pearl grey, or green of various degrees of intensity, mountain, leek, Asparagus, or olive, or clove brown, or intermediate between the flesh and rose red, or light or deep blue, or purple or iridescent; two of these colours often meet in the same specimen. That found in Spain is generally grey; the other colours are more frequent in Germany.

In Spain, it is found in extensive strata forming entire mountains; these strata offer vertical flatted striæ heaped on each other, and often intersected with quartz [†]. Sometimes also crystallized in Germany, and of a greenish colour. In Saxony, it is found in low hexahædral prisms with truncated edges and angles, the planes of the sides longitudinally seamed, or in hexangular tables heaped one on the other.

External lustre 2, 3. Internal 3, 2. Transparency 3, 2, 4.

Its cross fracture foliated; its longitudinal uneven, fine-grained, or tending to the conchoidal [‡]. Fragments 2.

Hardness from 6 to 7, brittle. Specific gravity of the *whitish sort* found in Spain, before it has absorbed water, 2,8249; after absorption, 2,8684, 7 Ann. Chy. 82; of the greenish, found in Spain, 3,098, 2 Berg. I. 1790, 75: of that found in Saxony, 3,218, Ibid. 76. The greenish crystals have often been mistaken for crysolites, sometimes for berylls, and sometimes for aigue marines. *Ibid.*

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[*] 2 Berg. I. 1790, 254.

[†] 33 Roz. 242.

[‡] 1 Bergm. I. 1788, 89. 2 Bergm. I. 1790, 75.

The greenish crystals, whose specific gravity is 3,098, do not phosphoresce when heated, nor decrepitate as spars do, and dissolve in nitrous acid with a weak effervescence. Per Werner, 2 Berg. I. 1790, 75.

I find he now calls them *spargel stein;* as the phosphoric acid has not yet been found in them, it is not certain that they belong to this species. Do they not belong to that of stronthian?

13th Species.—Combined with the Tungstenic acid.

Tungsten.—Insoluble in water, and neither effervesces nor dissolves in acids.

Pulverized and digested in a moderate heat, either with the nitrous or marine acid, it assumes a yellow colour.

Exposed to the blow-pipe, it decrepitates, but is infusible. Mineral alkali attacks it with some effervescence, and borax without any; but with microcosmic salt it runs into a bead of a blue colour, without that redness by refraction which is produced by cobalt.

It is decomposed by AR formed of equal parts of nitrous and marine acids in a boiling heat. By repeating this process with fresh portions of acid, the calcareous part is at length taken up. The tungstenic acid, that then remains undissolved, assumes a blue colour when heated to redness, and loses its usual yellow colour, becoming white by the affusion of caustic volatile alkali. It possesses, in a word, all the other properties of tungstenic acid *.

Specific gravity 5,00 to 6,07. Hardness from 8 to 9.

Of this fossil there are a few varieties.

1st Variety.—Grey Tungsten, Scheelium of Werner, white Zin-Graupen of many.

Colour, whitish or pearl grey, rarely yellowish grey.

It is found both amorphous and crystallized; the crystals cubic, or aluminiform octohædral.

Lustre, 3.2. Transparency, 2.—Fracture, foliated.—Hardness 8 to 9. Specific gravity from 5,8 to 6,028, which is that of the specimen Leske, O. 3261.

By the experiments of Mr Scheele, who first discovered the nature of this stone, it contains about 30 per cent. of pure calx, a few grains of silex and iron, and the remainder tungstenic acid. Scheele, § 2. 3. Messrs. Eluyart have found nearly the same proportion in the tungsten of Schlackenwald in Bohemia. See their Memoir, § 5. in note.

2nd Variety.—Brown Tungsten †. Gossan of the Cornish Miners.—Reddish or yellowish brown, or grey mixed with reddish or yellowish brown.

Amorphous or forming a brittle accumulation of small crystalline grains.

Lustre, 2.—Transparency, 0.—Fracture, uneven, granular, and partially splintery, sometimes slaty.—Hardness, 8.—Specific gravity

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* 4 Berl. Beob. 321.

† 4 Berl. Beob. 320.

5,570.—Gives a powder of an Isabella yellow colour.

According to Mr. Klaproth, it contains 88 per cent. of tungstenic acid, 11,5 of pure calx, and half a grain of argill and calx of iron.

Note. The red or flesh-coloured stone of Rytershutte, which with Cronsted I suspected to contain the tungstenic acid, is now found to consist only of calx, 24 per cent. of iron, and of silex 22. See *Ferricalcites*.

This species may perhaps more justly be considered as an ore of tungstenical substance, of which we shall treat in the 4th part of this work.

CHAP. VII.

BARYTIC GENUS.

1st Species.—Barolite, or aërated Barytes. Witherite of Werner.

This substance, as found at Anglesark in Lancashire, is described by Mr. Watt, junior, nearly as follows:

Its colour greyish white, sometimes inclining to milk white, and sometimes with a slight tinge of yellow, from a mixture of iron; seldom greenish, often invested with a reddish ochry crust.

It is found in solid masses, sometimes filling an intire vein, sometimes interspersed with baroselenite, frequently rounded or affecting that form, seldom crystallized. Of the crystallized

4 forms have occurred. As 1°, small crystals radiated as a star, half an inch in length, and very thin, appearing to be hexangular prisms rounded towards the point; the other varieties were the six-sided column pointed with a pyramid of the same number of faces; also the double six-sided and the double four-sided pyramid.

Lustre 2. Transparency 2.3.

Fracture, in one sense conchoidal, in another fibrous or striated, the fibres converging. Fragments, long splintery.

Hardness from 5 to 5. Specific gravity from 4,3 to 4,338.

Effervesces with acids, and is soluble even in the concentrated vitriolic in a strong heat, but precipitates into baroselenite by the affusion of water, Phil. Tran. 1784, 301, and 18 Roz. 300. —It dissolves in the nitrous acid 1,4 when diluted with 5 times its weight of water.—And in spirit of salt whose specific gravity is 1,034. —It does not decrepitate when heated, but loses its transparency, and, when viewed against the light, appears bluish green.—It will not lose its air nor burn to lime in the strongest heat, but is rather disposed to melt where in contact with the crucible; whereas artificial barytes easily burns to lime, probably because it contains more water. It will not melt even in the heat given out by pure air, as Mr. Lavoisier attests.—Fourcroy found it soluble in 4304 times its weight of water in the temperature of the atmosphere, but it required only 2304 times its weight of boiling water. 4 An. Chy. 64. —According to Dr. Withering 100 parts of it contain 20 of fixed air*; according to Fourcroy

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* Phil. Trans. 1784, 298.

croy only 10.4 An. Chy. 65. Dr. Withering's determination however seems more exact, being supported by a double proof.

It has lately been found, as I am informed, in Argyleshire; also on Schlangenberg in Siberia, and in the pit of Isaacfund near Freyberg in Saxony.

Mr. Werner has bestowed on this fossil the name of *Witherite*, in honour of Dr. Withering, who first discovered it; and for the same reason I should also follow his example, were it not already generally known under the name of *Aërated Barytes*. The specific gravity of artificial aërated barytes is, according to Bergman, 3,773. But he allows it a large proportion of water. Sciagr. § 88.

2nd Species.—Barytes combined with the Vitriolic Acid.

Baroselenite.—This substance requires 43000 times its weight of water to dissolve it in the common temperature of the atmosphere.

It is soluble in the concentrated vitriolic acid 1,87 in a boiling heat, and precipitable therefrom by the affusion of water. Phil. Trans. 1784, 303.18. Roz. 300, per Sage 1 part requires 12 of acid for its solution. Mem. Par. 1788.

Hardness, from 4 to 5. Specific gravity, when perfectly pure, according to Afswelius, 4,865. But in general it reaches only from 4,40 to 4,43; in temperature 60° an impure sort which contained only 55 per cent. of baroselenite, the remainder being silex, argill, and iron, had its specific gravity 3,892. The Swedish baroselenites are yet the heaviest, their specific gravity generally exceeding 4,5.

It is fusible *per se* by the blow-pipe, on charcoal it acquires an hepatic smell; and, when thus melted by pure air it gradually dissipates. —Mineral alkali melts it with effervescence, borax and microcosmic salt with scarce any; the first decomposes it, the two last extract no colour from it.

It does not form a plaster, as gypsums do; yet Gerhard denies this.

It contains about 84 per cent. of barytes; the remainder vitriolic acid and water, per Bergman. But artificial baroselenite contains 67 of earth and 33 of vitriolic acid and water, per Klaproth 2. Chym. An. 1785, 219, or 65 of earth and 35 of acid and water, per Fourcroy 4 Chem. An. 65. And Dr. Withering's experiments appear to me to prove, that 100 parts marmor metallicum contain 68,5 pure earth and 31,5 acid, as strong as that contained in tartar vitriolate. See Phil. Trans. 1784, 304. According to Dr. Withering's own calculation, 100 parts of this stone contain 67,2 of pure barytes, and 32,8 of vitriolic acid, which agrees almost exactly with Klaproth's determination.

Baroselenite is frequently contaminated with selenite, silex, iron, and aërated calx, and hence sometimes slightly effervesces with acids.

To analyze and purify it, Mr. Afswelius uses the following processes:

1st. After pulverization, it is mixed and calcined with 2,5 times its weight of aërated mineral alkali, perfectly pure and deprived of its water of crystallization, in a red heat for one hour and an half, avoiding fusion. A double decomposition thus takes place.

2nd. Glauber's salt and the superfluous alkali being then separated by lotion and coction, the residuum is boiled for 3 hours in 10 times its weight of distilled vinegar, whose specific gravity is 1,033. This takes up not only the barytic, but also the calcareous and muriatic earths if any, leaving only the argillaceous and ferruginous.

3d. To this solution vitriolic acid is added as long as any precipitation appears. This precipitate contains baroselenite, and possibly gypsum: this last is separated in 50 times as much water as the precipitate weighs, and the baroselenite remains single. When dried in a red heat, it contains 67 per cent. of pure barytes, which is separated by calcining it again with mineral alkali, dissolving it in nitrous or marine acid, and precipitating the solution with an aërated fixed alkali.

The whitest and heaviest baroselenite is the purest.

Of this Species we may distinguish 5 families.

1st *Family.—In an earthy loose form.*—Yellowish or reddish white, rarely pure white, consists of coarse dusty particles, mostly forming slight concretions, seldom in powder. Feels coarse, rough, and harsh, but appears weighty.

2nd Family.—Compact Baroselenite. Dichter Schwer Spath of Werner.

Yellowish white, or yellowish, reddish, bluish or blackish grey, or pale red, or Isabella yellow. Amorphous, in nodules, or in half-rounded masses, or tessular.

Lustre, 0.1. Transparency 1.0.

Fracture generally splintery, not rarely passing into the granularly foliated.—Sometimes earthy.—Fragments, 3.1.—Hardness from 5 to 6, rarely 4.—Specific gravity from 4,3 to 4,4. —Feels meagre.

It scarcely occurs without considerable impurities.

To this family belongs the baroselenite of Wignäs in the province of Dalin in Sweden. Afswelius § 10.—Colour reddish, form tessular, fracture presents indistinguishable particles; it is opaque, and its specific gravity is 4,3. It contains 71 per cent. baroselenite, 11 of selenite, 13,5 silex, one-half martial argill, and 4 of water. It decrepitates when heated.

Also the heavy stone of Ramelsberg is of this family; colour bluish grey, passing in some parts into the blackish grey. Dull, opaque, and of a splintery fracture, sometimes verging to the granularly foliated or sparry. Specific gravity 4,313. By Mr. Westrumb's Analysis, it contains 83 per cent. baroselenite, 65 silex, 4 calx of iron, 25 selenite, 1,5 alum, 2 of water and bituminous substance. 2 Bergbau 47.

At Wilieza in Galicia this stone is found beautifully waved and twisted, it assumes a polish like alabaster.

A compact baroselenite, found at Waldstein near Faistritz in Stiria, abounds so much in silex that it gives fire with steel. N. Act. Petrop. 1785, 363.

3d Family.—Foliated.—White, or bluish, reddish, or yellowish white, or yellowish, reddish or bluish grey, or flesh red, or verging on the brownish red, or Isabella yellow, rarely greyish black; the crystallized sort is often bluish grey, wine yellow, more rarely olive green, and still more rarely azure, verging in some parts on the green.

It occurs either amorphous, or crystallized in such various forms that even the patient Werner despairs of enumerating them; the most remarkable are the quadrangular prism, the hexangular prism, the double quadrangular pyramid, the quadrangular table bevilled at the edges; the surface of the crystals is generally smooth.

Lustre 2.—That of the crystals commonly 3.—Transparency 2.1.3.—That of the crystals 4.3.

Fracture either granularly foliated, or broad foliated, seldom curved foliated.

It generally presents thick lamellar distinct concretions, mostly straight, seldom curved, thicker commonly at one end than the other, owing to the accumulation of several lying on each other, and having a similar direction, which often gives the stone a radiated appearance.

Its fragments tend often to a sparry form.—Hardness from 5 to 6. Specific gravity from 4,3 to 4,8.

It is generally the purest of the species.

The Derbyshire caulk is of this family. Colour white, grey, or reddish, composed of rhomboidal laminæ set in different directions. Specific gravity 4,330.—It contains, by Dr. Withering's account, 99,5 per cent. of baroselenite and 0,5 of calx of iron.

Semitransparent quadrangular prisms of this family, analyzed by Mr. Afswelius, afforded him 79 of baroselenite, 6 of selenite, 3 of silex, 4 argill and iron, and 1,5 water.

White rhomboidal lamellar crystals from Kilpatrick hills near Glasgow, whose specific gravity was from 4,402 to 4,44, contain, by Dr. Withering's account, the purest baroselenite, 100 parts affording 67,2 of pure earth and 32,8 of vitriolic acid. His analysis is a model of skill and accuracy *.

Foliated baroselenite aften bears a strong resemblance to felspar, and I make no doubt has often been mistaken for it. See Leske, K. 137.

4th Family.—Striated or Fibrous.—Yellowish white, or bluish grey, or brownish or reddish yellow.

It occurs in somewhat rounded masses, of uneven surface.

Lustre, silky, or waxy, 2. Transparency 2.1.

Fracture striated, converging to a common center.

Hardness 5. Specific gravity from 4,000 to 4,4409.

The Cawk of Shropshire, analyzed by Dr. Withering, is of this family: he found in it 97,7 per cent. of baroselenite, and 2,3 of calx of iron.

Under this head we may also place the celebrated Bolognian stone, its specific gravity is 4,440 per Brisson. According to Mr Arvidson, it contains 0,62 of baroselenite, 0,16 silex, 0,15 argill, 0,06 selenite, and 0,02 water. 2 Chy. Ann. 1788, 205.

The Stalactitic baroselenites may also be reckoned as of this family; for instance, the tubuliform, whose cross fracture is fibrous, and their longitudinal foliated.

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* Mr. Werner has of late distinguished, and with great propriety, the lamellar, and granularly foliated. The granular differs from the foliated as granular limestone from calcareous spar.

5th Family.—Acicular. Stangen spath of Werner.

Colour, white, or whitish grey, or pale blue.

It is found in the form of needles, heaped together sometimes parallel, but often confusedly. Most commonly inhering in other stones. The surface of these needles is longitudinally streaked.

Lustre 2.3. Transparency 2.1.

Hardness 5. Specific gravity as of the foregoing families.

Mr. Bergman found these needles to consist of pure baroselenite. Schwed. Abhand. 1784, 111. They much resemble certain white-lead ores.

3d Species.—Liverstone. Lapis Hepaticus, Leberstein.—Colour, grey, greyish, or yellowish grey, or brown, or greyish black.

Lustre 2. 1. Transparency 1.

Fracture foliated and partly striated.—Hardness from 5 to 6. Specific gravity by my trial 2,666. It emits a smell of liver of sulphur when rubbed or heated to redness.

It does not effervesce with acids.

According to the analysis of Mr. Bergman, a specimen from Andrarum in Scania contains 0,38 of baroselenite, 0,33 silex, 0,22 alum, 0,07 gypsum, and 00,5 mineral oil. Sciagr. § 90.

The specimen, Leske, O. 1519, effervesces with acids, and therefore is not a liver-stone.

Neither is the specimen O. 1518 free from a calcareous mixture.

CHAP. VIII.

MURIATIC GENUS.

UNDER this head I include not only those earths and stones in which magnesia predominates, but also those in which the siliceous earth predominates, if magnesia be, next after this, the most copious ingredient, and the compound possesses the characters of the muriatic and not those of the siliceous genus.

1*st Species.*—Magnesia mixed with Silex. Silicimurite.

1*st Family.—Keffekill. Myrsen. Meerschaum* of Werner.—Neither pure nor aërated magnesia unmixed with any other substance have as yet been found. Of the magnesia, separated by art from other combinations, 100 parts contain about 55 of mere earth, 30 of aërial acid, and 15 of water, when of the dryness possessed by that usually found in the shops.

Keffekill or myrsen, which the Germans corruptly call Meerschaum, is said to be when recently dug of a yellow colour, and as tenacious as cheese or wax. By the latest accounts it is found near Burza in lower Asia*. It is the substance of which the large Turkey tobacco pipes are formed. It is said to be the earth called in Canada *terre à chalumeau*, but of this I doubt. When boiled with grease it is formed into pipes, and hardens in the open air. The scrapings of these pipes were examined by Mr. Weigleb, and found to consist of one-half silex and one-half magnesia nearly; the magnesia did not effervesce with acids, this was probably occasioned by the expulsion of fixed air during the treatment with fat. To this also the hardness may perhaps be ascribed, as magnesia and silex will not harden even in a porcelain heat. 3 Crell. N. Entdeck, 3.8. By the heat of pure air this substance is converted into a white porcelain mass.

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* N. Acta Petropol. 1785, 263.

Note. Baron Born, 1 Raab 244, considers this earth as a semi-indurated talc.

2nd Family.—Martial Muriatic Spar.— Mr. Monnet, a mineralogist of considerable note, lately discovered this stone at *St. Marie aux Mines*, and called it *pisolites;* but, as a very different compound is generally denoted by this name, I have called it martial muriatic spar, a name which agrees better with its properties.

It is of a hard, solid, and sparry texture, of a grey, ochry, dull colour, but internally bright: it gives fire with steel, yet effervesces with acids.

In a strong heat it grows brown, but at last melts *per se*. Hence it must contain something else than magnesia, silex, and iron.

100 parts of it are said to contain 50 of silex, the remainder mild magnesia and iron, but in what proportion is not mentioned. 13 Roz. Suppl. 416.

2nd Species.—Magnesia mixed with a notable proportion of calcareous earth and some iron.

Calcimurite.—Colour, blue, or olive-green, of the consistence of clay; the latter contains no argill, but merely calcareous earth and magnesia tinged by iron; the former contains a larger proportion of calcareous earth; both are found near Thionville; the former is used by potters. 13 Roz. 60.

3d Species.—Mild magnesia mixed with clay and iron.

Argillo-Murite.—Colour, greenish yellow; consistence, earthy. Found in Silesia, and by Mr. Margraaf's experiments contains one-third of its weight of magnesia. 2 Theile 18. Another sort has been discovered in Italy by Mr. Fabroni, of which I have seen only the analysis; it contains 0,50 of silex, 0,13 magnesia, 0,10 argill, 0,03 calx, 0,009 calx of iron, 0,08 water. Of it the ancients made bricks so light as to float on water. 12 An. Chy. 316. Its consistence is very loose.

4th Species.—*Chlorite. Samt Erde.* Peach of the Cornish miners.

1st Family.—*In a loose form.*—Colour, grass-green, or greenish brown, or dark-green inclining to black.

It is found in scales either investing other stones or heaped together.

External Lustre, 0,1:—feels greasy,—shews a white streak,—gives an earthy smell when breathed on.

It melts into a dull black compact slag, and then becames magnetic. By the analysis of Mr. Hæpfner it contains 0,4375 magnesia, 0,375 silex, 0,0417 argill, 0,0166 calx, and 0,1299 iron. 2 Sauss. 133.

2nd Family.—Indurate and crystallized.—Colour, dark green, almost black. Form oblong, quadrangular, and acuminated.

Lustre, 1. Transparency, 0.

Fracture earthy, yet somewhat scaly. Hardness, 6. Not remarkably heavy. Gives a mountain green streak. Feels meagre. Does not effervesce with acids.

Ferb. Briefe 43.

According to Hæpfner, it contains 0,415 silex, 0,3947 magnesia, 0,0613 argill, 0,015 calx, 0,1015 iron, 0,015 air and water. 1 Chy. An. 1790, 56.

*3d Family.—Slaty**.—Of this sort I have seen no authentic description. It is said to abound with garnets and magnetic iron stone. According to Baron Born, 1 Raab 247, its colour is greenish grey. According to others, dark green, inclining to black.

Internal Lustre, 1.2. Transparency, 0.

Fracture, more or less perfectly slaty, sometimes curved slaty, or passing into the scaly foliated; and then accompanied with more lustre, and a darker colour. Fragments, flatted.

Gives a mountain green streak, feels smooth and somewhat greasy.

Hardness, 5.4.

5th Species.—Talc.—Of this Species we have 3 families.

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* Lenz. 76.

1st Family.—In a loose semi-indurated form.

Talcite.—Colour, reddish or greenish white, or leek green.

Found in the form of small scales, loose or slightly coherent.

Lustre 3.4.

Feels somewhat greasy, adheres to the fingers, and, when rubbed in, gives a gloss to the skin.

Very light.

Does not effervesce with acids.

The name *Talcite* has been bestowed by Wallerius, Baron Born, and others, on a very different substance. But it is more properly applicable to this.

2nd Family.—Talc. Or common Talc. Venetian Talc.—Colour, generally greenish-white. or pale apple green, verging on the silvery white, more rarely reddish-white, by transmitted light it appears green.

Frequently occurs in oblong nodules of an irregular surface.

Lustre, nearly metallic, 4. Transparency, 2. 3. or if very thin, 4.

Fracture, foliated, straight, curved, or undulating. The lamellæ, easily separable from each other, if straight, but not if curved or wrinkled. The lamellæ flexible, but not elastic.

Hardness, from 4 to 5. Specific gravity from 2,7 to 2,8 by my trial on the specimen Leske, O.

Feels somewhat greasy. Does not effervesce with acids. Strongly heated, it becomes whiter, less transparent, and more brittle. Fixed alkalis scarcely flux it, borax and microcosmic salt are more effectual. Pure air melts it into an opaque greenish mass, spotted slightly with red.

The few experiments I formerly made on this substance seemed to indicate the presence of silex, magnesia, and argill, with a very small proportion of iron; but they are too imperfect to be relied on. I am happy to find it has been since analyzed by Mr. Hæpfner; he found it to contain 0,50 silex, 0,44 magnesia, and 0,06 argill. 4 Helvet. Mag. 296.

The crystallized talc of Baron Born, 1 Raab 247, seems to me to be rather *chlorite;* and, though he wishes to confound this with talc, yet they must be distinguished, since the one is fusible by the blow-pipe, the other not.

3d Family.—Shistose Talc. Schiefriges Talc, Leske, O. 1154, 194.—Colour, whitish grey, or greyish green, or dark green, or bluish grey.

Surface uneven and wavy, the lamellæ being in many parts broken or worn away.

External lustre, 2. 3. Internal lustre, 1. From a number of shining particles dispersed through it, sometimes in certain positions, 3.

Transparency, 0. except the whiter sort, whose transparency is 2.

Fracture, hackly, long splintery, and irregularly slaty.

Hardness, from 4 to 6. Brittle. Specific gravity from 2,7 to 2,8.

It becomes white and scaly by exposure to the air. Feels soft, and easily crumbles when rubbed in the fracture.

6th Species.—Steatites.

1st *Family.—Semi-indurated. Craie de Briaçon. Specstein of Werner.*—Colour, greyish, yellowish, or greenish white, rarely pure white mostly having a shade of green, particularly when moistened, (the white often contains black dendritical figures), or yellowish white speckled or veined with red, or mountain, olive, or leek green, or slate blue.

It is found in amorphous masses, rarely crystallized in hexangular prisms, terminated with an hexangular prism *.

Lustre, 0. Transparency, 0. or scarcely 1.

Fracture, earthy, or coarse splintery. Hardness from 4 to 5. Specific gravity, before it has absorbed water, is according to Brisson, from 2,61 to 2,79. And after absorption from 2,66 to 2,794. But perhaps this last may belong to the next family, if so, the specific gravity of this will only reach to 2,66 or 2,69 when penetrated with water.

It absorbs, but does not diffuse itself in water.

It either does not adhere, or scarcely adheres to the tongue.

It feels soft and greasy, and takes a polish from the nail.

Does not effervesce with acids.

Hence we see it resembles fullers earth; it differs chiefly in not being diffusible in water, in possessing some slight degree of transparency, and being somewhat harder.

When heated, it hardens and whitens, but does not melt at 150°.

The steatites of Suartwick, examined by Mr. Bergman, seems of the kind we now treat; its colour green, felt greasy, and might be scraped by the nail. Microcosmic salt had not the power of fluxing it, but it yielded to borax, and with effervescence to mineral alkali. He found it to contain 0,80 of silex, 0,171 of aërated magnesia, 0,02 argill, and 0,009 calx of iron. 4 Bergman, 166. I suspect, however, from its hardening in fire, that it contains more argill.

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* Q.?

The white steatites of Cape Lizard in Cornwall, which is streaked with red and blue, of the hardness of cheese, and used for porcelain, seems also of this kind. Mr. Klaproth found it to contain 48,42 per ct. of silex, 20,84 magnesia, 14 argill, 1 of iron, and 16 of air and water. 1 Berl. Beob. 163, 192.

2nd Family.—Indurated Steatites.—Lardites of Wallerius.—Schmeerstein of Succow.— Colour, yellowish, or greenish grey, often veined or spotted with a deeper yellow or red.

External lustre, 2.1. Internal, 0. Transparency, 2. 2,5.

Fracture, fine splintery, often mixed with imperfectly conchoidal. Fragments, 2.

Hardness from 5 to 6. Specific gravity of a specimen I tried was 2,784. That of a specimen tried by Mr. Brisson, which he calls *pierre de lard*, was before it had absorbed water 2,583, and after absorption 2,632.

Feels greasy, and often resembles soap.

This seems to be the stone analyzed by Mr. Weigleb, 2 Chy. An. 1784, 429, under the name of steatites of Bayreuth, for he refers to Margraaf, 2 Theile, p. 15, whose description answers to that of this. He found it to contain per ct, 58,33 of silex, 39,16 magnesia, and 2,5 iron. It is remarkable that he found no argill.

The steatites of China, Leske, O. 1102, is of this family. Margraaf says it is often called Spanish chalk ; it may therefore be the same as the Spanish chalk of Brisson, whose specific gravity he found to be 2,790.

3d Family.—Foliated or Striated.—Talcites of Wallerius.—Colour, leek green, passing on the one hand into the mountain green, and on the other through the olive green, into the sulphur yellow.

Generally found in independent amorphous masses, sometimes investing or intersecting serpentines, &c.

External lustre casual, but commonly 3, Internal, metallic in the dark coloured, or waxy, in the higher 3. Transparency, 2.1.

Fracture, foliated, mostly curved foliated; sometimes striated, particularly when investing, or intersecting. Fragments cuneiform. Hardness from 6 to 7.

Brittle. Specific gravity of the specimen I tried, Leske, O. 1111 is 2,636. That of the *talcite* of Brisson (which he says is composed of white mica, whose layers are agglutinated, but seems to be the same as that now described), before it has absorbed water, is 2,6325, and after absorption 2,6496.

Gives a pale greenish grey streak.

Feels greasy. Does not adhere to the tongue.

This description, is for the most part taken from Mr. Kürsten, who very properly distinguishes this fossil from common steatites.

Heated to redness, it becomes grey and

harder, and at 147° forms a grey porous porcelain mass.

7th Species.—Pot-Stone.—Lapis Olaris.—Verharteter Talk, or Topfstein of Werner.—Colour, light or dark greenish grey, or greenish and reddish grey, or yellowish grey, or speckled with red, or leek green.

Lustre, 2. 1. 3. Transparency, 1. 0. 2.

Fracture, undulatingly foliated, or the folia exceeding thin, and discovering rugosities; often also slaty.

Fragments, long splintery, or plated.

The foliated present sometimes gross or minute distinct concretions.

Hardness from 4 to 6, brittle. Specific gravity of that of Como, the most famous of this species, is 2,8729. According to Saussure, that of Switzerland has its specific gravity 3,023. Some absorb water, the specific gravity of the pot-stone of Dauphiné, which is of slaty structure before the admission of water, is 2,7687, after admission 2,8214; of the Swedish, before the admission of water, 2,8531, after admission, 2,8629.

Feels greasy.

This stone is often confounded with indurated steatites, which possibly may have been applied to the same use, but whose characters and composition are very different; it is more difficultly distinguished from shistose talc, especially where the pot-stone is slaty, yet their lustre, specific gravity, and feel, are different. The slaty abounds in common talc. See the specimen, Leske, O. 1157.

By the analysis of Mr. Weigleb, the potstone of Como, contains about 0,38 silex, 0,38 magnesia, 0,07 argill, 0,5 iron, 0,01 aërated calx, and still less of the sparry acid*; but, as the quantity of air and water is not given, we can form no true idea of the proportion of these ingredients to the whole, but only of that in which they stand to each other. The fluor acid and calx are in too small proportion to affect the essence of the stone. It differs therefore from steatites principally in this, that the magnesia and silex are in a larger proportion to each other, and the iron to both.

8th Species.—Serpentine†.—Most commonly of a dark blackish, or leek, olive, or canary green, seldom sulphur yellow, sometimes blood, carmine, or peach blossom red, often bluish, or greenish grey, or brownish red, or reddish brown, or greyish blue.

These colours are scarce ever single, but 2, 3, or more accompany each other (and hence the stone derives its name), one, or two, form the ground; and one, or more of the others, form specks, veins, or dots therein; in these not only the above colours occur, but also black, and more rarely the scarlet red, crimson red, and canary green.

It is almost always found in an amorphous independent state, seldom disseminated, and inherent.

Lustre, 0. Transparency, 1.0.

Fracture, fine, or coarse splintery, which sometimes pass into the uneven of a fine grain.

Fragments, between 2 and 3.

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* 3 Helvet. Magaz.

† The Germans and French call it also *Serpentine*; but the latter call also a sort of porphyry or variolite *Serpentin*.

Hardness from 6 to 7. Somewhat brittle. Specific gravity, according to Brisson, reaches, before it is penetrated with water, from 2,2645 to 2,709. It is only those whose specific gravity is beneath 2,6 that admit water. He indeed mentions one which he says is fibrous and semitransparent, whose specific gravity is 2,9997; but this cannot be a serpentine, as neither of the three characters belong to it; nor do I believe that of Dauphiné, which he says is semitransparent, to be a serpentine, but rather an indurated steatites. The specific gravity of the dark reddish brown serpentine of Zoblitz, Leske, O. 1137, to which a small quantity of talcite, adheres, I found to be 2,561 and that of the dark blackish green, also of Zoblitz, Leske, O. 1130, to which also some talcite adheres, 2,574.

Most give an earthy smell when breathed on.

It feels rather soft, almost greasy.

Most serpentines discover in their fracture yellowish or canary green scales, particularly those that otherwise resemble trap. See Leske, O. 318, 319, 321. These also often contain garnets, which trap never does. It is distinguishable from indurated steatites by its opacity, colour, hardness, feel, and generally by its specific gravity. By reason of its earthy smell, I suspect that it has often been mistaken for trap, from which it differs most widely.

When heated it hardens and reddens, but is infusible by the blow-pipe. By a heat of 136° I found the blackish green, Leske, O. 1130, hardened to 9, and turned to a reddish brown; at 150° it became greyish white, and formed a semicompact mass of the nature of porcelain. Hardness 10. The dark reddish brown at 163°

imperfectly melted, forming at the surface a grey opaque enamel, but internally a porcelain mass.

Mr. Knock found a serpentine, whose specific gravity was 2,684, to contain per cent. 45 parts silex, 33 magnesia, 14 magnetic iron, 6,25 aërated calx, one-fourth argill, with a little salited magnesia and water. 2 Chy. An. 1790, 497. Meyer found a serpentine he examined, to contain silex and magnesia, with a little iron, and a suspicion of calx. 1 Chy. An. 1790, 342. Klaproth found no argill in the serpentines of Saxony, 4 Berl. Beob. 187. Hence I am inclined to think, that serpentines contain no argill except accidentally, but merely silex, magnesia, and iron. The silex in the proportion of about 5 or 4 to 3 of magnesia. The proportion of iron variable from 4 to 15. The experiments of Mr. Bayen, though accurate, were not made with a view to precision; it was only by induction that I found the quantity which I formerly stated. In pot-stone, iron seems also to be essential, but the silex and magnesia approach nearer to an equality. In steatites, iron is merely casual, and never in any considerable proportion. The ratio of silex and argill to each other is not settled, but water seems essential to the semi-indurated.

9th Species.—Asbestus.—Asbeste non mur of the French.—Colour, generally leek green, often olive or mountain green, more rarely greenish grey, or dark, or light yellowish grey. Lustre, 2.1. Transparency, 1. or, if very thin, 2.

Fracture, parallel, or divergingly, and generally somewhat curved striated, or fibrous, the fibres coarse or delicate; sometimes inclining to, or intermediate between, the fibrous and splintery.

splintery*. Fragments for the most part long splintery.

Hardness from 6 to 7. The limits of its specific gravity are, according to Buffon, pretty distant, one specimen of a light grey colour which he calls *asbeste mur*, had its specific gravity before it had absorbed water, 2,577, and after absorption 2,699. Another of the same colour, which he calls *asbeste non mur*, was before absorption 2,9958, and after absorption 3,0343. And that of divergingly fibrous asbestus, which he calls *asbeste étoilée*, was before absorption 3,0733.

I found that of the specimen from Zoblitz, Leske, O. 1184, to be 2,547. I believe the heavy sorts mentioned by Brisson were actinolytes.

Feels somewhat greasy. Gives a grey powder, and streak.

Does not effervesce with acids.

The specimen Leske, O. 1184, which is of a yellowish green colour, was hardly discoloured by a red heat; at 160° it formed a grey, somewhat porous porcelain, whose surface was enamelled, and gave fire with steel, therefore it began to be fused. Mr. Saussure found the asbeste he tried affected in the same manner. 1 Sauss. 86.

Mr. Bergman comprehends stones of many different species under the name of asbestus; and hence it is difficult to assign the numerous and exact analysis he has made of them, to the different species to which they severally belong;

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* See Pabst's Catalogue, by Werner, No. 2730. Werner, in Cronsted, assigned it a striated fracture, but now a fibrous. See Lesk's and Pabst's Catalogues, and 1 Bergm. I. 1789, 162.

a clear proof of the necessity of exact descriptions of the external characters of fossils. The asbestus of Bastnäs seems to be that of which we here treat, as he refers to Cronsted, § 105.2 this he says afforded him 67 per ct. silex, 16,8 aërated magnesia, 6 aërated calx, 6 argill, and 4,2 iron. 4 Bergm. 168.

Another from Grænge in Dalecarlia, Cronst § 106 contained 63,9 silex, 16 aërated magnesia, 12,8 aërated calx, 1,1 argill, and 6 calx of iron. Ibid. 170.

Another from Pehrsberg in Wermeland, contained 62 silex, 13,7 aërated magnesia, 12 aërated calx, 1,7 argill, and 10,6 calx of iron.

Mr. Weigleb, in the leek green asbestus of Zoblitz, found about 47 of silex, 48,5 mild magnesia, and 4 of iron. I tried this result synthetically, and found it to resist fusion at 148°.

Hence we see that few stones admit of a greater latitude of composition than this, as it admits some argill, and a pretty large proportion of aërated calx, into its composition; yet neither are essential to it. But the iron is in a calcined state, which distinguishes this stone, in that respect, from steatites, pot-stone, and serpentine.

10*th Species.—Ligniform Asbestus.*—Colour, brown, approaching to Isabella yellow.

Lustre, 0. Transparency, 0.

Fracture, slaty, and, if broken across, it discovers an irregular filamentous structure, like wood.

I have not seen it, nor do I know whether it has any other similitude to wood, or asbestus. I place it here only by reason of its name.

Mr. D'Aubenton has proposed a good criterion for distinguishing petrified wood. He observes, that mere concentric layers are not sufficient, there must also be lines intersecting these layers, as the medullary prolongations from the center to the bark.

11th *Species.—Amianthus.*—Colour, most commonly greyish, or greenish white, more rarely yellowish or silvery white, sometimes olive or mountain green, or pale flesh red, or ochre yellow.

Lustre 1.2, sometimes 3, and then resembling the metallic. Transparency, 1.2.0.

Fracture presents delicate, and mostly straight and parallel, rarely curved fibres, sometimes closely compacted. Its fibres flexible.

Fragments, long splintery.

Hardness from 3 to 4. Specific gravity before it has absorbed water, is, according to Brisson, from 0,9088 to 2,3134, and after absorption, from 1,5662 to 2,3803.

Feels somewhat greasy.

I found a specimen of the greyish white to melt at 162,5, into a greenish black, perfectly compact glass.

Mr. D'Arcet and Saussure found it to melt, and crystallize, at (I presume) a much lower heat; and at a higher, to run into a greenish glass.

The snow-white amianthus, of Tarentaise, was found by Mr. Bergman to contain 64 per cent. silex, 18,6 aërated magnesia, 6,9 aërated calx, 6 baroselenite, 33 argill, and 1,2 calx of iron. 4 Bergm. 163.

The stone from Suarwick, which he calls asbestus, but which, from the flexibility of its filaments, I judge to be an amianthus, afforded him 0,64 silex, 0,172 aërated magnesia, 0,139 aërated calx, 0,027 argill, and 0,022 calx of iron. Ibid. 165.

That which he calls asbestus of Corias, in Asturias, I take also to be an amianthus, as he says it is very like that of Tarentaise, and refers it to Cronstedt, §105. 1; in this he found 0,72 silex, 0,129 aërated magnesia, 0,105 aërated calx, 0,033 argill, and 0,013 calx of iron.

Another from Crete contained 53 per cent, of silex, 28,8 aërated magnesia, 14,3 aërated calx, 1 argill, and 2 calx of iron.

Hence we see, that asbestus and amianthus differ, not in their constituent parts, but in this, that amianthus contains them in a proportion more easily fusible; hence also asbestus passes into amianthus, when, by exposure to the air, it loses part of that ingredient, whose disproportion to the remainder renders it more difficultly fusible.

Note.—Amianthus has been found in a farinaceous state by Mr. Dolomieu, on the mountain St. Fiora, in Tuscany. See his notes on 3 Bergm. 246.

Amianthus in a crystallized form, namely, in rhomboids or compressed parallelopipeds, of a grey or bluish colour, are said to have been found in the neighbourhood of Bagneres; they are very soft and of a filamentous texture, but harden by exposure to the air. 26 Roz. 429.

12th Species.—Suber montanum. Corium montanum.—Colour, white, or reddish white, or yellowish grey, or Isabella, or ochre yellow, or yellowish brown.

It is found either in thick compact pieces, and then called mountain cork; or in thin flat pieces, then called mountain leather, or paper; or cellular, and then called caro montana, &c.

Lustre 0, rarely 1. Transparency 0.

Fracture presents fibres confusedly interwoven with each other, sometimes so subtile as to be difficultly distinguished, and thus they give the fracture a compact earthy appearance.

Hardness, 4. Takes an impression, or yields like cork to the finger, and somewhat elastic.

Specific gravity, before it is penetrated by water, from 0,6806 to 0,9933; and after admission of water, from 1,2492 to 1,3492. *Brisson.*

If perfectly dry, and sufficiently thick, it gives a sound when struck.

It feels meagre.

Bergman and Saussure found it fusible, though difficultly, by the blow-pipe. 4 *Bergm.* 169. 2 *Sauss.* 124.

By Mr. Bergman's Analysis it contains from 56 to 62 per cent. of silex, 22 to 26 aërated magnesia, from 2,8 to 12,7 argill, about 3 of calx of iron, and from 10 to 12,7 aërated calx.

13th Species.—Amianthinite. Asbestartiger Strahlstein of Werner, in part. Leske, O. 1186. 1188.—Colour, ash, or greenish or yellowish grey, often mixed with yellow, or red, or both, from decomposition.

Form, amorphous.

Lustre, of the grey part, silky, verging to the semimetallic 3. Transparency 0.

Fracture, presents a confused appearance of the foliated and fibrous, the fibres so faint as to be scarcely distinguished, presenting distinct concretions, irregularly bundled, and in the gross often obscurely slaty.

Hardness from 2 to 4. Specific gravity of the specimen Leske, O. 1186, that which was the purest was 2,584, that of another, Leske, O. 1188, which was mixed with iron, ochre, and pyrites, 3,872.

The purer specimen melted at 154° into a brittle porous opaque black shining mass; the heavier being heated to redness became partly purple, and partly brownish red; and at 147° melted partly into a compact slagg, and partly agglutinated into a porous brittle mass.

14th Species.—Asbestinite. Gemeiner Strahlstein of Werner. Leske, O. 1190, 1199, *S.* 374.—Colour, white with shades either of red, yellow, or green, or blue.

Amorphous.

Lustre, silky, approaching to the semimetallic, 3. Transparency, 1, 2.

Fracture, shattered foliated, or broad striated, sometimes faintly seamed.

Presents oblong distinct concretions, running in different directions.

Hardness, from 5 to 6. Specific gravity from 2,806 to 2,880.

At 150° melts into a green glass.

It is sometimes disguised by a thin crust or illinition of black manganese, which exhibits the same radiated appearance.

15th Species.—Asbestoid.—Of this I distinguish two families.

1st Family.—Common Asbestoid. Gemeiner Strahlstein of Werner. Leske, O. 1191-2-3-5-7-8, and 1200, and *S.* 373.—Colour, olive or leek green, when decomposing reddish brown.

Amor-

Amorphous.

Lustre, common 2, when glassy 3, when decomposing 0. Transparency, 0.1.

Fracture, sometimes foliated, sometimes broad-striated, the striæ diverging from one or more central points.

The foliated may even be considered as tending to, or departing from, a common center.

Hardness from 6 to 7. Specific gravity from 3 to 3,31.

At 160° it melted into an opaque, black compact glass.

This seems to be the stone analyzed by Mr. Weigleb, and in which he found 43 per cent. silex, 22 magnesia, and 34 of iron, and some traces of the sparry acid. 1 Chy. An. 1785, 21.

2nd Family.—Metalliform Asbestoid. Asbestartiger Strahlstein of Werner, in part. Leske, O. 1187.—Colour, grey, or inclining to the reddish grey.

Amorphous.

Lustre, semimetallic, 3. Transparency, 0.

Fracture, foliated, or what some would call broad-striated; often seemingly converging to a common center.

Hardness from 8 to 9. Specific gravity, 3,356.

At 152° melts into a compact black glass.

16th Species.—Lamellar Actynolite. Asbestartiger Strahlstein of Werner. Leske, O. 1189.—Colour, dark yellowish, or greenish grey.

Amorphous.

Lustre, in some positions feeble, in others 3 and glassy. Transparency, 0, or scarcely 1.

Fracture, the shattered foliated, the edges of the broken lamellæ give, however, a striated appearance.

Hardness 7, brittle. Specific gravity 2,916.

By a red heat it becomes in some places whiter, in others redder, and upon the whole harder.

At 168° it melts into a dark green compact glass.

It has a strong resemblance to hornblende.

17th Species.—Shorlaceous Actynolite. Gemeiner Strahlstein of Werner, in part. Leske, O. 1194, 1196, 1201.—Colour, leek or dark green. External lustre, 3.4. glassy internal, 1.2. Transparency, 2.3.1.

Crystallized generally in long, slender, quadrangular, hexangular, or (apparently) triangular, prisms, with perfectly smooth surfaces; or rather pyramids, being thicker at one end than at the other, and hence called *strahl,* or *arrow stones.* Sometimes a small pyramid adheres longitudinally, and, as it were, grows out of a larger; sometimes many adhere together. In Siberia, it is said, some are found 5 feet long, and 15 inches thick. 1 Chy. Ann. 1785, 265.

Fracture, hackly.

Hardness from 7 to 10. Specific gravity from 3,023 to 3,45.

The specimen, Leske, O. 1196, whose specific gravity was 3,023 melted at 154° into a dark green compact glass.

18th Species.—Glassy Actinolyte. Glassartiger Strahlstein of Werner.—Colour, leek green, or (from decomposition) verging to the

greenish

greenish white, or silvery white, or stained with yellowish, or brownish red.

External lustre, 3.4. sometimes glassy, sometimes silky. Internal, 0. Transparency, 2.

Crystallized in slender compressed quadrangular or hexangular pyramids, or fibres, closely and longitudinally adhering to each other, straight or incurvated, or consisting of fibres undulatingly incurvated, and adhering in the same manner.

The face of the fracture of single pyramids cannot be discerned, that of the collection is hackled; but the longitudinal fracture is fibrous, the fibres sometimes parallel, sometimes diverging, and often from many central points.

Fragments, long splintery, and exceeding sharp, so as to be difficultly handled without injury.

Hardness, difficult to estimate, on account of their brittleness. Specific gravity, of some specimens that had a glassy lustre, I found to be 2,950, of the specimen 1205 Leske, O. which has a silky lustre, 3,493.

The last mentioned specimen melted at 149° into a compact dark green, almost black glass.

But the specimens that were crystallized in needles, of great subtlety, but whose planes and angles were still discernible as those in Leske, O. 1203, 1204, melted at 137° into a grey, somewhat porous mass, and 159° into a yellowish grey compact porcelain, with an enamelled surface, and began to act on the crucible.

The substance, called by Mr. Bergman, the *fibrous shorl of Grænge,* seems to be of the sort of which we here treat. It is, he tells us, of a green, bordering on white, and consists of slender parallel transparent fibres, brittle as glass; and melts into a scoriform mass. In this he found 72 per cent. of silex, 12,7 of aërated magnesia, 6 of aërated calx, 2 argill, and 7,3 of calx of iron. 4 Bergm. 171.

The *fibrous shorl* (as he calls it) of Zillerthal, in Tyrol, seems also of this species; it contains by his analysis 64 per cent. silex, 20 aërated magnesia, 9,3 aërated calx, 2,7 argill, and 4 calx of iron. *Ibid.* 172.

We may also vindicate to this species the stone called by Mr. Saussure *shorl en filets brillants et fragiles*, so sharp as scarcely to be handled with impunity. In it he found 0,5525 silex, 0,3018 argill, 0,1087 unaërated magnesia, 0,0484 unaërated calx, and 0,0148 of iron. 2 Sauss. 470. Here not only the large proportion of argill is remarkable, Mr. Bergman having scarcely found any, but that magnesia and calx should be *unaërated*, whereas Bergman in all the stones of this genus found them *aërated* *.

The great specific gravity of these stones, considering the moderate proportion of iron found in them, also deserves attention. May not the new earth, called stronthian, be found in them? and may it not have been mistaken for calx?

19th Species.—Jade. Nephrit of Werner. Bitterstein of Hœpfner, and others.—Colour, generally dark leek green, or verging to blue, or in some prominences inclining to the greenish, or bluish white; and even the greener parts, when fresh broken, discover pale whitish splinters, sometimes yellowish white, with a light shade of green.

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* Of the six foregoing species I have given the descriptions from my own observations; they are all comprehended by Mr. Werner, under the name of *strahlstein*, and of them he makes three divisions, the asbestine, common, and glassy. The arrangement I have followed seems to me more exact, though not out of the reach of cavil.

Found in detached rounded masses, or inhering in rocks.

Surface, often smooth, often somewhat uneven.

External lustre, 1, waxy. Internal 0, or scarcely 1. Transparency 2, 1.

Fracture coarse or fine splintery; yet often discovers here and there a few fibres somewhat incurvated. Fragments 3.4.

Hardness 10, not brittle. Specific gravity of the specimen Leske, O. 1116, which came from the East-Indies, by my trial, 2,977. Brisson found that of green jade 2,9660; and that of whitish, or olive-coloured jades, from 2,950 to 2,9829. Mr. Saussure found those of oriental jades from 2,970 to 3,041; but the jades of Switzerland he found still heavier, namely, from 3,31 to 3,389. He also found them harder.

It feels greasy.

According to Dolomieu it becomes more transparent and brittle when heated. 40 Roz. 215.

But it is said to be infusible in the strongest heat of our furnaces.

According to the analysis of Mr. Hœpfner, it contains 0,47 silex, 0,38 aërated magnesia, 0,04 argill, 0,02 aërated calx, and 0,09 iron.

20th Species.—Baikalite.—Its colour, olive green.

Crystallized in quadrangular, hexangular, or octohædral prisms, terminated with an oblique pyramid; the octangular have four broad, and four narrow sides. From two to ten inches long, and from half an inch to four inches thick. Surface smooth, seldom longitudinally streaked.

Lustre 1.2. Rather greasy; often in some positions mutably resplendent. Transparency, 0.1.

Fracture, splintery, passing into the conchoidal. Fragments, 2.3. Hardness, 8.9. Specific gravity, 2,200. Gives a white streak.

Does not effervesce with acids, except some calcareous particles be contained in the rifts.

When heated, it sometimes reddens, and at last melts into a dark green glass.

By the analysis of Mr. Lowitz, it contains 0,44 silex, 0,30 magnesia, 0,20 calx, 0,06 calx of iron, and, casually, fluor acid.

This stone has as yet been found only on the borders of the lake Baikal, in Siberia, from which it derives its name *. Some have called it *shorl*, others *crystallized hornblende;* but the absence of argill, and the quantity of magnesia it contains, to say nothing of its external characters, prove it to be a distinct species of the muriatic genus.

21*st Species.—Combined with the Boracic Acid, and boracited Calx.—Boracite* *.—Colour greyish white, sometimes passing into the greenish white, or purplish.

Hitherto it has been found only in cubes, whose angles have been more or less deeply cut off.

Their size scarcely exceeds half an inch The surfaces generally somewhat corroded.

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* 2 Bergm. Journ. 1790, 284. 2 An. Chy. 102, 137. 3 Berl. Beobacht 1.

The external lustre, if the surface be smooth, 3; if rough, 0. Internal, greasy, 2.

Transparency (except it be covered with an opaque rind) 2.3.

Fracture, compact, and of the small flatted conchoidal kind. Fragments, 3.

Hardness, 9, 10. Specific gravity, 2,566.

Exposed to the strongest heat, it contracts, and at last melts into a yellowish glass.

It does not effervesce, nor dissolve in acids, unless heat be applied.

Abbé Hauy, has discovered that it becomes electric by heat, like tourmaline; but the discovery of its component parts, one the most important and least expected hitherto made in mineralogy, was reserved for Mr. Westrumb; he found it to contain 0,68 boracic acid, 0,13 magnesia, 0,11 calx; 0,01 argill, 00,1 silex, and 0,01 iron. The three last he justly considers as casual.

The mountain of Kalkberg, near Luneburg, is the only place that as yet affords it. It is there seated in a bed of gypsum.

CHAP. IX.

ARGILLACEOUS GENUS.

1st Class.—*Argillaceous Earths.*

These are for the most part diffusible in water, and do not immediately sink in it as sands do; or if so compact as immediately to

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[*] Chy. Annal. 1793, 22. 5 Crell Beytr. 4 Stuk. 407.

sunk,

sink, they soften, crumble, or moulder away in it, some sooner, some later, either to a ductile viscid pulp, or to a powder.

Hardness, scarce ever exceeds 6; they harden when heated; scarce ever effervesce with acids, and are difficultly soluble in them.

As earths originally received their denominations from external and not from internal characters, they cannot now, without creating much confusion, be arranged according to their real specific properties, if any such could be assigned. But in fact none such can, except fusibility or infusibility, which depend on proportions and ingredients both mutable and casual. Hence I shall sort them under the title of different tribes; marking the cases in which these are found to be more or less fusible, or adapted to various uses.

1*st Tribe.—Native Argill. Lac Lunæ of some. Reinethon Erde of Werner.*—Colour, pure white.

Found in nests, in compacted rounded kidneyform masses.

Lustre, 0. Transparency, 0.

Fracture, earthy. Fragments, 0. Hardness, 4, brittle. Specific gravity, moderate.

Feels meagre, but soft.

Adheres very slightly to the tongue, stains very slightly.

Does not readily diffuse itself in water.

Infusible at 166°.

It sometimes effervesces with acids, being saturated with fixed air, a circumstance which is rarely observed in earths of the argillaceous kinds; and to this union we may ascribe its meagre feel, slight adherence to the tongue, and little attraction to water. It is not perfectly pure; for, it was found by Mr. Schreiber to contain a very small proportion of aërated calx, and in some specimens a little gypsum, also some feeble traces of iron; but (as it seems) no silex, which distinguishes it from *clays* properly so called.

It has been found at Halles, in Magdeburg, and, as some say, at Verona.

Of Clays in general.—The constituent parts of clays are argill and siliceous stones, from the size of $\frac{1}{100}$ to $\frac{1}{1000000}$ of an inch. All other ingredients (except water), and there are many, are extraneous to its composition.

The proportion of these two ingredients to each other is variable; sometimes the argill exceeds, but most commonly the siliceous ingredient predominates. When the argill exceeds, its proportion to silex scarce ever reaches, but sometimes approaches, the ratio of 4 to 1; but more frequently subsists in the ratio of 3 to 1, or 2 to 1, or 1,5 to 1, or approaching still nearer to equality. When the siliceous ingredient exceeds, which is by far the commonest case, it is found at most, and very rarely in the proportion of 6 to 1, more commonly in that of 4 to 1; and still oftener to that of 3 to 1, or 2 to 1, more rarely it approaches an equality.

These proportions produce different effects. Thus the clays, in which the siliceous ingredient enters in the proportion of from 3 or 4 to 1, are best for porcelain, those in which the argill exceeds are best for coarse pottery; and particularly for the glass-house crucibles, as being less acted on by alkalis *.

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* 14 Ann. Chy. 143. 3 Neu. Entdeck. 13, 35.

The kind of siliceous stone which constitutes the sandy part of clay, should also be attended to; I believe it to be more frequently quartz, but it may also be hornstone, or felspar, or of various other species, which will much influence the internal properties of the clay. The nature of the sand should therefore be tried, after separating it as much as possible by washing. If the sand be of the quartz kind, it is best separated by boiling the whole in oil of vitriol, which will take up the argill and leave the quartz; but if it be a comminuted felspar, or other compound stone, this stone itself will be decomposed by that acid; so that the trial should rather be made on the part separated by washing.

The colours that occur in clays are very numerous, and depend on metallic, or vegetable, or bituminous, or coaly particles, pure clay being always white. The colours arising from the particles of a vegetable, coaly, or bituminous nature, are destroyed by heat in an open fire, and therefore are no way prejudicial to the finer uses to which clay may be applied; but those arising from metallic particles are most obstinate. Sometimes, however, the metallic particles are engaged only in the coarser sandy part, and may with it be separated by elutriation; sometimes they are picked out by the hand.

With respect to fusibility, we may remark, that clays, which contain only argill and silex, will melt in no heat that can be produced by our furnaces, in whatever proportion these two ingredients may be to each other.

But calcareous earth, in the proportion of 10 or 12 per cent. will render any clay fusible.

Calces of iron, if united to the argill, will render the clay fusible; but, if united to the siliceous part, and if this part considerably predominates, the clay will not be fusible.

It should seem, therefore, that an addition of pure silex to any clay in such proportion as not to destroy its ductility, would not render it fusible; the addition of lime, or calces of iron, would, on the contrary, render any clay fusible.

As the infiltration of water frequently conveys calcareous earth, and calces of iron, and as beds of coal obstruct this infiltration, hence the clays found under coal are generally the most infusible.

2nd Tribe.—Porcelain Clay. Kaolin.—Colour, white, greyish white, or reddish, or yellowish white.

Lustre, 0. Transparency, 0.

Friable and dusty, often compact.

Adheres very slightly to the tongue.

Feels soft but not greasy.

Hardness seldom exceeds 4; but lately some much harder has been found in Siberia. Maquart 430. Specific gravity (which is best taken when hardened by fire) varies with the proportion of its ingredients between 2,23 and 2,4. That of Limoges, which is worked without any mixture, has its specific gravity, 2,341. Brisson 273.

In water it immediately falls into powder. Those of Japan, and St. Iriez in France, are perfectly white; those of Saxony, reddish, or yellowish; those of China, and Cornwall, are mixed with particles of talc and mica.

In general porcelain earth is infusible in our furnaces, as Cronsted remarked; but, in manufacturing this earth, some fusible ingredient is commonly added; however, nature sometimes furnishes these ingredients with the earth, and to this compound we cannot refuse the name of porcelain earth. According to Mr. Hassenfratz, to whom mineralogy, in all its branches, and the arts therewith connected, are much indebted, the porcelain earth of Limoges above mentioned contains, when dried, 0,62 silex, 0,19 argill, 0,12 magnesia, and 0,07 baroselenite*. Mr. Wedgwood, in the porcelain clay of Cornwall, found on the contrary 60 per cent. argill, and only 20 of silex; this clay is therefore infusible. When dried by a summer heat, or that of a room moderately warm, it loses about $\frac{1}{100}$ of its weight; in the heat of boiling water as much more; in that of melted lead, and thence to a strong red heat, in which copper melts $\frac{10}{100}$, in all $\frac{12}{100}$; after that no more. The matter thus lost is common and fixed air, but no inflammable air. Hence it appears to differ from the first tribe only in containing silex.

3d Tribe.—Common Clays in various states of Induration.—Of this tribe Mr. Werner distinguishes three sorts, which I call families. Their ingredients may differ considerably, as they are denominated, from their external appearances only. They are all considered here in their purest state, and *dry*.

1*st Family.—Potter's Clay.*—Colour, generally greyish white, and then called *pipe clay*, or light yellowish, white, or grey, or dark bluish grey; more rarely brownish black, or pale reddish, or greenish grey, or mountain green, or ochre yellow, and often spotted only with this.

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* 14 An. Chy. 144.

Often found in large strata.

Lustre, 0. Transparency, 0.

Fracture, fine earthy, and, from a number of rifts, somewhat uneven.

It stains the fingers slightly.

It acquires some polish by friction.

It adheres to the tongue moderately.

It feels greasy.

Hardness, 3 or 4. Specific gravity from 1,8 to 2.

It is entirely diffusible in water; and, when duly moistened, very ductile.

When unmixed with metallic particles (which may be known by exposing it to a strong heat, as already mentioned) it is infusible at 160°; but it is not therefore fit for making porcelain; for this requires that the sandy part should be of the greatest fineness, and also that it do not retain water with obstinacy, which it always does when the argill is not combined with fixed air; and hence, I believe, we may derive the practice of exposing clays to the air for a long time, before they are employed.

It does not effervesce with acids, unless contaminated with mild calx or magnesia in a considerable proportion, and then is rather a marl. There are few clays, however, that do not contain some proportion of calcareous earth.

It is exposed to many contaminations from iron and pyrites; if iron be united to the argillaceous part, it is fusible.

The proportions of argill and silex vary considerably, as we have already seen.

2nd Family.—Indurated Clay. Verhärteter Thon of Werner.—Colour, grey, yellowish, bluish, or greenish grey, or brick or flesh red, or mountain green, or reddish brown, or blackish brown.

It frequently contains the roots of vegetables.

Lustre, 0. Transparency, 0.

Fracture, earthy, sometimes participating of the even, and sometimes of the splintery, and sometimes tending to the slaty. Fragments, 1.

Hardness, from 5 to 6. Specific gravity inconsiderable.

Slightly adheres to the tongue. Often feels somewhat greasy; often not. In water it does not diffuse itself, but gradually falls to pieces, or crumbles into powder, and discovers but little ductility. Some sorts do not moulder in many days.

It hardens when heated.

Sturbridge clay seems of this sort. Colour, dark grey; does not adhere to the tongue. I found 100 parts of it in the state of dryness in which it comes to us to contain 12,5 per cent. of moisture, 12 of coarse sand, partly white and crystalline, and partly brown and reddish brown, and 30 per cent. of a brownish sand, so fine as scarcely to be discerned through a lens. The argillaceous part was grey, and contained still more sand, which could not be separated but by boiling in acids.

Water quickly acts upon it, a white argillaceous part soon diffuses itself, and afterwards another part which is darker falls into powder; hence it should seem there are two sorts of indurated clay; the sandy, and the clayey.

3d Family.—Shistose Clay.—1st Variety.—Slate Clay, Shale. Shiefer Thon of Werner. —Colour, generally bluish, or yellowish grey, more rarely dark blackish, or reddish grey, or greyish black, or greenish yellow. Often found in strata, particularly in coal-mines, of which it is almost a sure fore-runner; it commonly bears vegetable impressions. Its surface generally knobby.

Lustre, externally it hath often some gloss, but none in its fracture, or only presents a few shining particles. Transparency, 0.

Fracture, slaty, sometimes bordering on earthy. Fragments, 2.

Hardness from 4 to 6. Specific gravity from 2,6 to 2,68.

Adheres slightly to the tongue.

Feels meagre or merely smooth. Gives a white or grey streak.

Gradually moulders and falls into powder in water; but the harder sorts very slowly. The harder as that in Leske, O. 786, melted into a frothy mass, partly lead coloured, and partly dark greenish yellow, between a porcelain and an enamel. Another specimen, Leske, O. 784, melted at 151° into a frothy mass, partly pearl grey, and partly liver brown, between porcelain and enamel.

When it contains mica it is not so probable an indication of coal. Voight, Prack. Gebirg. 85.

2nd Variety.—Bituminous Shale.—Brandshiefer of Werner.—Colour, brownish black, or blackish brown, and looks like bad coal.

Found in considerable stratified masses.

Lustre, 0, or 1. Transparency, 0.

Fracture, slaty; the slates mostly thin, often thick. Fragments tabular.

Hardness, 5. Specific gravity about 2000.

Its streak somewhat glossy.

It often effervesces, though very slowly, with the mineral acids.

Feels rather greasy.

Placed on burning coals, it burns with a weak flame, and sulphureous smell; the residuum is then light grey. It thus loses a considerable part of its weight. Some will hardly burn but with the assistance of bellows.

It seems to differ from the former variety, in containing bitumen.

The specimen in Leske, O. 961, has its specific gravity 1,995; and that of Leske, 959, has its specific gravity 2,053. Both effervesce, though very slowly, with acids.

It sometimes bears the impression of fish

4th Family.—Fuller's Earth.—Walkerede of the Germans, Smectis.—Colour, the fossil so called, has almost always some shade of green, commonly light olive, greenish grey, or greenish white, or greenish brown, more rarely yellowish grey, or greyish white. The greenish shade is made more visible when the earth is breathed on, or moistened. Flesh red has also been found in Saxony, but of an inferior quality.

Lustre, 0. Transparency, 0.

Fracture, earthy, often inclining to the uneven, sometimes to the slaty, sometimes fine earthy, and slightly participating of the conchoidal. Fragments, 0.

Receives a polish from friction.
Does not adhere to the tongue.
Feels somewhat greasy.
Hardness 4, almost friable.

In water it readily falls into powder without considerable diffusion, or forming a pulpy mass. Some imagine these earths should froth and lather with water, but though this possibly might sometimes happen, yet certainly not generally; for Mr. Werner denies this property to the fulling-earths of Saxony, Mr. Bergman to that of Hampshire, and Mr. Becker to that of Westerwalds*.

Mr. Bergman has given an accurate account of the fuller's earth of Hampshire; its colour is brown, with a scarce perceptible shade of green, and streaked with pale yellowish veins, with some slaty appearance. Water boiled on it for half an hour, though filtered, still retains so much of it as to diminish its transparency. In this water the solution of marine baroselenite discovers nothing vitriolic; but the solution of silver does indicate some traces of marine acid. If this earth be heated to redness, it blackens; but this blackness vanishes in a higher heat, which shews it to proceed from some vegetable or coaly matter. When heated it slightly decrepitates, and in a strong heat forms a brown spongy mass. Heated with microcosmic salt, it at first effervesces slightly, but afterwards is scarcely acted on; borax corrodes it better, but consumes it slowly. Soda attacks it with considerable effervescence. By his analysis it contains 0,518 silex, 0,25 argill, 0,033 aërated calx,

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* Werner, Cronst. 182. 4 Bergm. 155. 1 Berl. Beob. 20.

0,087 calx of iron, 0,007 aërated magnesia, 0,155 moisture, or volatile matter.

Though this earth contains 4 per cent. of substances that should effervesce, yet it does not effervesce with acids; which induces Mr. Bergman to think, that the calx and magnesia may be chemically combined with the argill, and not merely mechanically mixed as in marls. Some fulling-earths, it is said, effervesce slightly with acids*, but the best certainly do not; and it is plain from the small quantity of effervescible matter found in that of Hampshire, that neither the calcareous ingredient, nor the magnesia, do of themselves contribute in the least to the fulling property. The great use of this earth is to deprive the cloths of greasy substances with which they are impregnated, before they are soaped; this advantage they evidently derive from the argillaceous ingredient; this, therefore, should be sufficiently copious, not less than 20 or 25 per cent. and not too unctuous, for it would not then readily diffuse itself in water; perhaps, indeed, the union of the calx and magnesia contributes to this prompt diffusibility. The siliceous ingredient should be very fine, lest it should cut the cloth; this fineness is indicated by the polish the earth receives by rubbing it with the nail; hence any clay that possesses these properties may be used for fulling †; but a mixture of pyrites, or 3 or 4 per cent. of calx of iron, is hurtful.

In Saxony this earth commonly lies under mould; in England under sandstone or sand, and over sandstone or limestone; in Germany it has also been often found so situated; sometimes too in the neighbourhood of trap, or basalt, 1 Berl. Beobacht, 21.

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* 2 Gerh. Gesch. 350.

† 4 Bergm. 159. 2 Gerh. Gesch. 352. 1 Gensanne Hist. Nat. Langued. 158.

4th Tribe.—The finer clays in various states of induration.

1st Family.—Lithomarga, Steinmarck of the Germans.—These earths are principally distinguished by their great fineness, and fusibility into a frothy slagg.

1st Variety.—The friable or crumbling kind.—Colour, white, or yellowish, or reddish white.

Lustre, 1 or 0. Transparency, 0.

Seldom loose, most commonly moderately coherent, and formed of scaly or exceeding fine particles, and then adheres strongly to the tongue. Scarcely stains the fingers.

Feels very smooth Assumes a polish by friction with the nail.

Fracture, earthy, often uneven, and grossly conchoidal. Hardness from 3 to 4. Specific gravity exceedingly light.

In water it immediately breaks and falls into powder.

2nd Variety.—Indurated Lithomarga.—Colour, greyish, reddish, or yellowish white, or pearl grey, or flesh red, or brownish red, or yellowish, or reddish, or liver-brown, or ochre, or Isabella yellow, or bluish grey, or violet blue, or lavender blue, or spotted or veined with these different colours.

Generally found in nests or veins of rocks, or entering into the composition of aggregate stones as a constituent part.

Surface, frequently very smooth, polished, and fine and close grained, having the aspect of a stone.

Lustre, external, often 2; internal, 0. Transparency, 0.

Fracture, earthy, often conchoidal, more or less perfectly, or inclining to the even; nay, sometimes to the slaty. Fragments, 0; yet sometimes 2.

Hardness from 4 to 6, or even 7. I found the specific gravity of the harder sorts, 2,815.

The softer sorts adhere strongly to the tongue where newly broken, the harder sorts very moderately*.

Commonly feels very greasy, or at least smooth, yet some feel dry and dusty. Does not stain the fingers. The softer acquire a polish by friction.

The coloured give a streak, or powder of the same colour.

In water the harder sorts do not easily yield; but the softer immediately crumble. According to Cronsted, § 85, the characters of this earth are,

1st, A smooth soapy surface while dry.

2nd, A gradual disintegration in water; first into small pieces, and afterwards into grains, but not into a pulp, as happens to potters clay.

3d, In a strong heat, fusion into a frothy mass, which occupies more room than the crude earth had done.

4th, A lamellar, or rather, as Mr. Bergman quotes it, a conchoidal fracture.

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[*] 2. Bergm. J. 1788, 520.

The earth, called *mountain soap*, differs from this only in being softer, feeling more greasy, adhering more strongly to the tongue. Its colour is dark brown, or pearl grey; its fracture earthy, or participating of the earthy and conchoidal. Hardness, 4.

Mr. Bergman analyzed the grey Lithomarga of Osmund; its surface feels greasy, though somewhat uneven. It appears slaty, yet its fracture is conchoidal. Fragments sharp. Hardness 5; it is acted on by water as above-mentioned; does not lather, yet is detersive, it melts into a white frothy mass. It contains 60 per cent. silex, 11 argill, 5,7 aërated calx, 0,5 aërated magnesia, 4,7 calx of iron, and 18 of water and air.

The beautiful earth, called *terra miraculosa Saxoniæ*, is by Mr. Werner reckoned of this family; but, if fusibility be an essential property of lithomarga, this earth does not belong to it; for neither of the specimens, 1080, 1081, Leske, O. are fusible in a heat of 150°, but harden into a brittle blackish mass, and seemed to me to contain charcoal. The specimen 1880 possesses, indeed, all the other characters of the harder lithomargas; but the specimen Leske, O. 1079, feels dry, and scarcely adheres to the tongue; so that I consider it rather as an indurated clay.

A lithomarga phosphorescing when scraped, of a pearl colour, and somewhat semi-transparent, was discovered in the Hartz by Baron Trebra. 1 Chy. An. 1784. Lasius, Hartz 313. Is it not rather a mixture of lithomarga and bole?

3d Family.—Bole.—Colour, dark Isabella yellow, strongly inclining to brown, or pale liver brown, sometimes dotted or variegated with black spots, or dendritical figures, or reddish brown, seldom flesh red.

Lustre, 0. Transparency, scarcely 1.

Fracture, conchoidal. Fragments, 2.

Acquires a polish by light friction; scarcely adheres to the tongue; feels greasy.

Hardness, 4. Specific gravity from 1,4 to 2.

It immediately crumbles in water into powder, and not into pieces.

Mr. Bergman comprehends this earth under the head of Lithomarga, and gives the following account of Lemnian earth, which is one of the most noted boles. Colour, yellowish; surface, smooth and polished like agate; fracture, conchoidal; fragments, angular; grain, close and indiscernible; hardness, such as to admit being scraped by the nail. In water it falls to pieces; and these into powder; it does not froth like soap, but possesses a detersive power, like fuller's earth.

When heated to a sufficient degree it melts into a frothy scoria.

By his analysis it contains 47 per cent. silex, 19 argill, 5,4 aërated calx, 6 aërated magnesia, 5,4 calx of iron, and 17 of water and air. 4 Bergm. 157.

Hence we see, that all the softer sorts of lithomarga are detersive in some degree, and learn to value the *external characters* of Mr. Werner, which point out the best for the purpose of fulling.

4th Tribe.—Argillaceous Marls.—Colour, grey, yellowish, or greyish, or brown, or yellowish, or reddish brown.

Found in considerable strata.

Lustre, 0. Transparency, 0.

Fracture, earthy, sometimes slaty, sometimes conchoidal. Fragments, 0, 1, 2.

Hardness, from 4 to 7. Often shattery. Specific gravity, from 2,4 to 2,6.

Feel somewhat unctuous, and adhere to the tongue.

Effervesce with the mineral acids, but frequently refuse to do so with vinegar.

Moulder and crumble by exposition to the air, more slowly than calcareous marls, sometimes requiring 5 or 6 years.

When heated they harden into an imperfect brick, which is slowly disintegrated by water.

In a greater heat they form a slagg. However, if they contain a large proportion of sand, the bricks formed by them are quickly disintegrated by water.

They contain mild calcareous earth, in the proportion of, from one-tenth to one-fourth of the whole.

To Dr. Withering, of Birmingham, we are indebted for many well-directed experiments on these marls. He found,

1st, That a red compact marl, that was so plastic as to form and burn to a brick, contained one-tenth of its weight of mild calx.

2nd, A grey, in hard lumps, was also plastic, but gritty, and formed a soft brick; it contained one-sixth of its weight of mild calx*.

3d, A red, with grey spots, and very hard, contained about one-fourth of aërated calx; yet it was plastic and burned to a grey hard stone.

Mr. Andreas published a good dissertation on marls in German, in the year 1769, in which he distinguished marls as follows:

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* Phil. Trans. vol. lxiii.

1st, Marl, properly so called, consisting of equal parts of clay and mild calx, that is, chalk.

2nd, Calcareous marl, consisting of three parts chalk and one of clay.

3d, Argillaceous marl, consisting of three parts clay and one of chalk. Again, if the marl contains coarse sand, gypsum, or mica, he makes the following subdistinctions:

1st, Sandy marl; 2nd, Sandy calcareous marl; 3d, Sandy argillaceous marl.

Again, 1st, Gypseous marl; 2nd Gypseo-calcareos marl; 3d, Gypseo-argillaceous marl.

And lastly, Micaceous marl; Micaceous calcareous; and Micaceous argillaceous.

5th Tribe.—Colorific Earths, or those which strongly stain the fingers.

1st Family.—Red. Reddle. Rubrica fabrilis. Rothel, Leske, O. 973.—Colour, dark cochenille red, or intermediate, between brick and blood red.

Lustre, 0. Transparency, 0.

Fracture, earthy, sometimes conchoidal. Fragments, 1. Hardness, 4. Specific gravity, inconsiderable. Adheres pretty strongly to the tongue.

Feels rough; assumes a polish from the nail; strongly stains the fingers.

In water immediately falls to powder; does not become ductile.

Does not effervesce, nor easily dissolve in acids.

When heated to redness it crackles and grows black; at 159° the specimen, Leske, O. 973, melted into a dark greenish yellow frothy enamel.

It differs from red ochres only by containing more argill. The red colour proceeds from oxygenation and the absence of acid. The more air and water is expelled by heat, the browner it grows.

2nd Family.—Yellow. Gelbe Erde. Leske, O. 1098.—Colour, ochre yellow.

Lustre, externally often hath some gloss; but internally none. Transparency, 0.

Fracture, earthy, often inclining to the conchoidal. Fragments, 0.

Hardness, 3. Specific gravity inconsiderable.

Adheres strongly to the tongue; feels smooth, or somewhat greasy; takes a high polish from the nail; strongly stains the fingers.

In water it immediately falls to pieces with some hissing; and afterwards to powder, but does not diffuse itself through it.

It does not effervesce with acids, nor is easily soluble therein.

Heated to redness it crackles, hardens, and acquires a red colour; gives a reddish streak. At 156° I melted the specimen, Leske, O. 1098, into a liver-brown porous porcelain mass.

This yellow earth differs from ochres only in containing a greater proportion of argill; the yellow colour proceeds from the calx of iron; highly oxygenated, and probably containing both water and acid. The earths that contain a larger proportion of iron have rather an orange colour.

According to the analysis of Mr. Sage, of Paris, who has the merit of preserving to his countrymen the immense gains the Dutch acquired by converting this yellow earth into what is there called *English red*, it contains 50 per cent. argill, 40 calx of iron, 10 of water, acidulated by vitriolic acid. Mem. Par. 1779, 313.

3d Family.—Black. Black Chalk. Schwartze Kreide, Zeichen Schiefer, Leske, O. 972. *Pierre noir, of Brisson,* p. 163.—Colour, greyish black.

Lustre, 0. Transparency, 0.

Fracture, imperfectly curved slaty. Fragments, 1; partly flat, partly long splintery.

Hardness, 5, specific gravity 2,114, by my trial; per Brisson 2,186 before absorption, 2,277 after absorption of water.

Adheres slightly to the tongue, feels smooth, assumes a polish from a knife, gives a black streak, and marks black.

In water does not readily moulder; but if taken out it cracks in a short time.

Does not effervesce with acids, or easily dissolve therein.

Heated to redness it crackles and becomes reddish grey.

It contains somewhat vitriolic.

4th Family.—Green Earth. Leske, O. 1013. —Colour, greyish green.

Found generally in lumps in the cavities of other stones, or externally investing them.

Lustre, 0. Transparency, 0.

Fracture, earthy, sometimes uneven; sometimes verging to the conchoidal. Fragments, 2.

Hardness, from 6 to 7. Specific gravity 2,637.

Sometimes feels smooth; but often scarcely; does not assume a polish from the knife, nor adhere

here to the tongue, nor stain the fingers, nor mark while dry, and when wet but lightly.

In water it often crumbles after standing about half an hour.

Does not effervesce with acids, nor is easily soluble therein.

Heated to redness it crackles and becomes of a dark reddish brown colour; at 147° the specimen, Leske, O. 1013, melted into a black compact glass, resembling that of basalt. This shews it to consist of silex, argill, iron not much oxygenated, and calx of nickel, from which the green colour is derived, besides water.

Of Umber.—A brown or blackish substance, very light, which moderately stains the fingers, and strongly adheres to the tongue; has long been taken for a sort of clay: but Mr. Hupsch, in the Memoirs of Berlin, for 1777 (and, long before that, Dr. Hill, p. 63), has shewn it to consist chiefly of particles of decayed wood, mixed with bitumen. This name hath also been given to an ochre of the same colour, which becomes red when slightly heated; but in a stronger heat again becomes brown; and in a still stronger melts into black glass It is therefore a compound of clay and iron, but in which the iron is the prevalent ingredient. It does not effervesce with acids before torrefaction; but after that operation the martial part is easily acted on.

Differences of the foregoing Earths.—As the distinctive characters of earths are found variously combined in the earths above described, their discrimination will be much assisted by shewing the properties that distinguish each from all the others.

Native Argill is distinguished,

From *Porcelain earth,* often by its colour, or effervescing with acids, and its crystalline appearance when viewed through a lens, its more meagre feel; but best by its almost total solubility in vitriolic acid.

—— *Potter's clay,* by the above properties, and a slighter adherence to the tongue.

—— *Indurated clay,* by its colour, cohesion, and absence of sand.

—— *Slate clay,* by its colour, cohesion, fracture, and infusibility.

—— *Fuller's earth,* by its colour, meagre feel, and infusibility.

—— *Friable lithomarga,* by its meagre feel, slight adhesion to the tongue, and infusibility.

—— *Indurated lithomarga,* by its colour, cohesion, meagre feel, and often by its dulness.

—— *Boles,* by its colour, opacity, fracture, and meagre feel.

—— *Marls,* by its colour, fineness, cohesion, absence of calx and sand.

—— *Colorific earths,* by its colour, inadhesion to the tongue or fingers.

Porcelain Clay is distinguished,

From *Potter's clay,* often by colour, always by its friability, inunctuosity, fineness and lighter adherence to the tongue, and lesser diffusibility in water.

From *Indurated clay,* by its colour, degree of cohesion and fineness.
—— *Slate clay,* by colour, degree of cohesion, fracture, and fineness.
—— *Fuller's earth,* by colour, degree of cohesion, and inunctuosity.
—— *Friable lithomarga,* by moderate adhesion to the tongue.
—— *Indurated lithomarga,* by its degree of cohesion, of adherence to the tongue, and by colour.
—— *Boles,* by its colour, fracture, inunctuosity.
—— *Marls,* by colour, fineness, ineffervescence with acids.
—— *Colorific earths,* by colour, inadhesion to the fingers, fineness.

Potter's Clay is distinguished,

From *Indurated clay,* by its degree of cohesion, adherence to the tongue or fingers, unctuosity, and diffusibility in water.
—— *Slate clay,* as from the last mentioned; and also in fracture.
—— *Fuller's earth,* by colour, adhesion to the tongue, unctuosity, suspensibility in water.
—— *Friable lithomarga,* by its inferior fineness, smoothness, and adhesion to the tongue; and its superior hardness and suspensibility in water.
—— *Indurated lithomarga,* by its inferior fineness, hardness, smoothness, lustre, and fracture; and also by its greater diffusibility in water, as well as ductility.
—— *Boles,* by its colour, adhesion to the tongue,

tongue, inferior fineness; and also by fracture and diffusibility.
—— *Marls,* by its fineness, hardness, and ineffervescence with acids.
—— *Colorific earths,* by its colour and intinctivity.

Indurated Clay is distinguished,

From *Slate clay,* by its fracture, and commonly by its colour.
—— *Fuller's earth,* by its hardness, fracture, inferior unctuosity, and friability, and disintegration in water.
—— *Friable lithomarga,* sufficiently by its hardness.
—— *Indurated lithomarga,* by its inferior fineness, lustre, adhesion to the tongue; and often in the fracture and unctuosity.
—— *Boles,* sufficiently by its superior hardness and fineness; and also by its fracture.
—— *Colorific earths,* sufficiently by its intinctivity.

Slate Clay is distinguished sufficiently,

From *All others,* by its fracture, form and colour.

Fuller's earth is distinguished,

From *Lithomargas,* by its adhesion to the tongue, inferior fineness, (and often) hardness.
—— *Boles,* by its colour, fracture, opacity, and inferior unctuosity.
—— *Colorific earths,* by its intinctivity.

Friable Lithomarga is distinguished,

From *Boles,* by adhering to the tongue, by friability, and generally by fracture, colour, and hardness.
—— *Marls,* by its fineness, adherence to the tongue, and ineffervescence.
—— *Colorific earths,* by its intinctivity.

Indurated Lithomarga is distinguished,

From *Boles,* by adherence to the tongue, opacity, and generally colour; often by hardness.
—— *Marls,* by its fineness and ineffervescibility.

These earths, however, are often mixed, and consequently must exhibit mixed characters; but by an attentive consideration of these the families so mixed may be inferred and discovered. The arbitrary imposition of names, without any precise enumeration of the properties denoted by these names, has already introduced much confusion in mineralogy; Mr. Werner has laboured very successfully in removing it; the denominations should therefore in future be taken in the sense to which he has confined them.

6th Tribe.—Harsh and rough Earths.—Of these are two families. Tripoli, and Pouzzolana, or Terras.

1*st Family.—Tripoli. Hill* 67.—Colour, generally pale yellowish grey, or Isabella, or pale ochre yellow, or pale or reddish brown, or greyish, reddish, or yellowish white, seldom greenish white.

It is found in a loose earthy, but oftener in an indurated, consistence.

Lustre, 0. Transparency, commonly 0; yet that of the harder sorts, if wet, often 1.

Fracture, earthy; in the harder sorts inclining to the flat conchoidal, sometimes verging to the slaty. Fragments, 0, 1.

Hardness from 4 to 7. Specific gravity of the harder sort, after sufficient absorption of water, 2,529*. Feels harsh, dry, and frequently dusty; slightly, or scarce at all, adherent to the tongue; takes no polish from the nail; does not stain the fingers.

In water the softer sorts soon crumble into powder; the harder sorts imbibe it, but crumble slowly.

It does not effervesce with acids, unless mixed with marl, as it frequently is.

It frequently reddens when heated.

Mr. Haasse found this earth to contain 0,90 silex, 0,07 argill, and 0,03 iron.

Another stone, seemingly of this kind, though differing in some respects, was analyzed by Mr. Klaproth, its colour was whitish grey; its fracture, from a number of horizontal rifts, seemed slaty; to the touch it was meagre, and adhered strongly to the tongue. Its specific gravity, 2,080; it imbibed water strongly. He found it to contain 0,665 silex, 0,07 argill, 0,025 calx of iron, 0,015 magnesia, 0,0125 calx, and 0,19 air and water. 2 Chy. An. 1790, 302.

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* The specimen, whose specific gravity I determined, was that in Leske, O. 981.

It is often of pseudo-volcanic origin, as appears from the Paris Memoirs, of 1769, 276; and perhaps also sometimes really volcanic; but it also frequently arises from the decomposition, or disintegration, of other stones.

2nd Family.—*Pouzzolana, or Terras.*—Of this I shall treat under the head of Volcanic Products.

Slate Clay *.—This is a sort of clay lately noticed, and described by Professor Struvius, and found in those elevations that afford salt springs, and therefore worthy of particular attention.

Colour, dark bluish grey, inclining to black.

Found in considerable masses.

Lustre 0, except in the rifts, and there 2. Transparency, 0.

Fracture, earthy, yet unequal, discovering thick curved laminæ irregularly compacted.

Fragments, obtuse-angled.

Hardness from 4 to 5. Specific gravity inconsiderable.

It stains slightly, adheres somewhat to the tongue, and feels somewhat greasy.

Besides argill, it contains some magnesia, and calcareous earth. It is plainly only a variety of slate clay.

Miscellaneous Observations.—Coloured clays of the common or coarser kinds, which are by French writers called *glaise*, were found by Mr. Morveau to contain some contamination of the vitriolic acid; but in white clays he could discover none. 1 Encyclop. Chym. 122.

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* Bergm. Journ. 1791, 244.

This acid is probably united to the ferruginous particles that are found in those clays, and to which they owe their colour and fusibility. The *yellow,* however, sometimes derive their colour from regulus of antimony, bismuth, lead, silver, or zinc. Rinman, Hist. Ferri § 197.

Blue clays and marls sometimes whiten when heated, and consequently owe their colour to volatile matter, coal, or bitumen; but some redden, and contain pyrites. This trial should be made before they are used as a manure; as the first are innocent, the last hurtful. Neither Beaumé nor Woulfe could find any vitriolic acid in some blue clays, most probably in those of the first kind, and possibly not even in the second, as the barytic test, the nicest of all, was not known when their experiments were made.

Mr. Bergman found copper and cobalt in some blue clays; from others Mr. Rinman extracted 13 per cent. of iron, and 4 of lead, besides some traces of zinc. § 201.

Black clays are sometimes bituminous, sometimes pyritous.

Dr. Watson, in his elegant and useful tracts, vol. ii. p. 288, mentions a singular clay (or rather earth, since it contains no sand), which burns to a white brick. It contains 25 per cent. of aërated calx, 2,2 selenite, with a small quantity of calx of iron, the remainder argill. However, as this clay was not treated with vitriolic or any mineral acids, which alone can separate the argillaceous from the siliceous parts, it is probable, it still contained sand of great fineness. I also believe the selenite to have been formed during the drying.

Of *brick clay* the colours are various, reddish,

dish, bluish, brown, or yellowish; the best is that which, when burned, has the fewest cracks, and this depends on the proportion of sand it contains; if it contains too much, the clay will not be sufficiently ductile; if too little, the bricks will be rifty; and in that case more fine sand should be added. Therefore, potter's clay, if sufficiently sandy, will serve; the best proportion is, I believe, 0,86 silex to 0,14 of argill. Argillaceous marls are also very proper, but they should be well burnt to vitrify the calcareous part; but calcareous marls vitrify too easily, and therefore require an addition of clay. The coarse martial clays, that contain scarce any calcareous particles, are best; when slightly burned they are reddish, when more, they become yellow, or browner. Salt thrown into the kiln when at its greatest heat, will vitrify the surfaces of the bricks, and prevent their absorbing water.

This clay often contains selenite, which is decomposed by the common salt contained in mortar, and hence the glauber salt found efflorescing on bricks. This is also decomposed by the joint action of fixed air and lime; and hence the efflorescence of mineral alkali.

Volatile alkali has often been found in clays and earths, particularly in those that contain iron; a circumstance which had long puzzled mineralogical writers; but which has of late been happily explained by Dr. Austin, whose premature death cannot be too much deplored. He has shewn, by well contrived experiments, that when inflammable air, in its nascent state, slowly and gradually meets mephytic air, they combine and form vol. alkali. Now iron, in its metallic state, sojourning with water, always extricates inflammable air; which meeting with the mephytic part of the common atmosphere, thus forms volatile alkali.

2nd Class.—Stony substances of the argillaceous genus not mouldering in water.

1st Species.—Argill combined with vitriolic acid, or sulphur.

This forms ores of alum, and shall therefore be considered in the 2nd part of this treatise.

2nd Species.—Argill combined with the phosphoric acid.

Phospholite.—The stones, commonly called *Valentia garnets,* are suspected by Mr. Proust to be of this species. I have seen no description of them; they may be the garnets of Spain, mentioned in 1 Raab's Catalogue, p. 155. These are of the colour of hyacinth, transparent, and of a dodecaedral figure; exposed to the blow-pipe they burst; but in a moderate heat they swell like borax, whiten, and become so light, as to swim on water, after which they are difficultly fusible. 1 Ann. Chym. 196.

3d Species.—Lepidolite. Lilalite of some.—Colour, in the mass, is violet blue, but in thin laminæ silvery white.

Lustre, pearly, 3. Transparency, 1,5.

Fracture, straight foliated. Fragments, 2.

Presents fine-grained distinct concretions, easily separable.

Hardness, from 4 to 5. Brittle. Specific gravity, 2,816.

Before the blow-pipe it melts with a moderate spumescence into a white semitransparent enamel; with mineral alkali it slightly effervesces, and affords a red and blue spotted mass. Microcosmic salt gradually dissolves it; borax more readily; the first into a white, the last into a clear colourless pearl.

Exposed to a red heat for half an hour, it acquires an Isabella yellow colour, and loses about 1 per cent. of its weight; in a melting heat it forms an opaque reddish grey enamel, glittering in the fracture, and loses 25 per cent. of its weight.

By the analysis of Mr. Klaproth it contains 54,5 per cent. of silex, 38,25 of argill, 00,75 of iron and manganese, 2,5 of water and air. He found a loss of four grains, which arose from the dissipation of some unknown matter which caused its fusibility.

4th Species.—Sappane. Cyanite of Werner.—Colour, bluish grey, or partly greyish blue, partly greenish or yellowish grey, streaked with azure or deep blue, often in some spots reflecting a silvery white.

Lustre, pearly, 2.3. Transparency, when thin, 3.

Fracture passes from the divergingly broad striated, into the curved foliated.

Fragments 2, long splintery.

It is found of thin distinct lamellar concretions, which are in part accumulated in grains, feels somewhat greasy.

Hardness from 6 to 9. Brittle. Specific gravity from 3,092 to 3,517. That of the specimen which I examined, which is the greyish blue, Leske, O. 1185, was 3,092; that of the specimen examined by Mr. de Saussure 3,517.

Heated to redness it became whiter, and had a more talky appearance; at 157° it became almost perfectly white, but looked duller, and betrayed not the smallest inclination to fusion. It is difficultly fused by borax, scarcely by microcosmic salt, and not at all by fixed alkalis. According to Mr. Saussure, jun. it is composed of 0,6692 argill, 0,1325 magnesia, 0,1281 silex, 0,0171 calx, and 0,0548 iron. The calx seems an adventitious ingredient.

Mr. Struvius, in Crell's Annals for 1790, gives a very different account of the composition of this stone; for, according to him, it contains 0,515 silex, 0,305 magnesia, 0,055 argill, 0,04 calx, 0,05 iron, 0,035 water or loss. But his experiments not being detailed, nor his method known, I cannot set his analysis in competition with that of Mr. Saussure, which appears to have been carefully and skilfully executed.

5th Species.—Mica, Muscovy Talc, Glimmer of the Germans.—Its colours are, grey, or yellowish, or greenish grey, or silvery white, or yellowish, or reddish brown, or copper red, or gold yellow, or mountain green, or greyish, or greenish black, or leek green; but blue it seems has not as yet been seen.

Generally found interspersed, or associated with other stones, as in granite, gneiss, or, though rarely, crystallised in hexagonal plates.

Lustre, commonly metallic, 3, 4. Transparency in thin pieces 3.4.2; in thicker 1.

Texture generally curved or undulatingly foliated, more rarely straight foliated, still seldomer striated, chiefly broad striated.

Fragments, flat, present sometimes thick, sometimes oblong granular concretions. Its lamellæ flexible, and in some degree elastic; feel smooth, but not greasy.

Hardness 6. Specific gravity various; that of muscovy talc, which consists of broad colourless leaves, is, according to Brisson, 2,7917; most other sorts absorb water; the specific gravity of the white, before absorption, 2,704; after absorption, 2,749; that of yellow mica before absorption, 2,6546; after absorption, 2,7037; that of black before absorption, 2,9004; after, 2,9386; that of crystallized black mica, 2,9342. *Ibid.* Hence we see the coloured micas absorb from $\frac{1}{154}$ to $\frac{1}{54}$ of their weight of water, which accounts for their decomposition when exposed to the influence and variations of temperature of the atmosphere.

Mr. Saussure at first found all sorts of mica fusible into a semitransparent glass, black, brown, or greenish, and slightly porous. 1 Sauss. 95. However, he afterwards found colourless micas convertible only into a white enamel. 2 Sauss. 136. Mr. Sage found muscovy glass infusible in the strongest heat; in my trials some bits of muscovy glass were barely agglutinated in a heat of 163°; though they had a porcelain grain, and appearance, yet they were barely softened, not melted; with the help of pure air, however, this substance forms a white glass. Hence we may infer, that even colourless transparent micas are not all homogeneous, some being more fusible than others; coloured micas are fusible in much lower heats;

they are little affected by soda, but borax and microcosmic salt effect their fusion.

According to Baron Born, the brownish pellucid mica of Siberia contains 50 per cent. silex, 45 aërated magnesia, and 5 argill. 1 Raab. 238.

Mr. Werner also informs us, that the micas in gniess often afford steatites by their decomposition; consequently they must contain silex, argill, and magnesia.

I found 100 parts of the colourless kind to contain, 38 silex, 28 argill, 20 magnesia, and 20 of the most perfectly calcined iron; so I deemed it, from its colour and the great difficulty I experienced in dissolving it. This proportion, however, may admit of some doubt, as I had not then devised the more accurate method of estimating the real contents of precipitates by the Prussian alkali; but as to the other ingredients I do not suspect that any mistake could have happened in estimating their proportion to each other.

6th Species.—Micarelle, Leske, O. 999.—Brownish black.

Found in granite.

Lustre, metallic, 3. Transparency, 0.

Fracture, broad foliated.

Hardness, 6. Specific gravity, 2,980 by my trial.

At 153° it melts into a black compact glass, its surface reddish.

By its external characters, except specific gravity, this stone would be taken for mica; its analysis, however, shews it not to be so, as the argillaceous ingredient too much exceeds the muriatic, which sometimes is even entirely missed. Bergman found one specimen to contain 0,46 argill, 0,40 silex, 0,05 unaërated magnesia, and 0,09 manganese and iron. Swed. Abhand. 1784, 113.

Mr. Klaproth found another to consist of 0,63 argill, 0,295 silex, and 0,0675 iron. 2 Bergm. Journ. 1790, 229. Hence the presence of magnesia is merely casual; therefore it must be regarded as a distinct species from mica, and hence I have given it the name of *micarelle*.

7th Species.—Hornblende. Pierre de Corne of the French. Schorl en Masse, and Shorl Spathique of Brisson.—Colour, black, or greyish black, or blackish green, or dark olive green, or leek green.

Lustre, 2. Transparency, 0.

Fracture, sometimes straight, or curved, or divergingly striated; sometimes small or broad, straight or curved foliated[*].

Commonly with long-grained, more rarely with curved lamellar distinct concretions.

Fragments, 2; those of the lamellar variety affect a rhomboidal form.

Streak, greenish, or greyish green.

Hardness, from 5 to 9, scarcely reaching nine. Specific gravity per Brisson, from 2,922 to 3,3852, that of Leske, O. 1027, I found 3,41.

At the heat of 89° a piece of the above specimen melted into a black solid glass with grey spots; at a lower heat it baked into a greenish grey mass, between a porcelain and an enamel.

In the year 1783 I analyzed a piece of the foliated kind, and found it to contain 0,37 silex, 0,22 argill, 0,16 magnesia, 0,02 calx, (both the last aërated), and 0,23 of iron, not much oxygenated.

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[*] Its cross fracture, conchoidal, Leske, G. 297. Anmerk.

In 1787 Mr. Weigleb found another specimen to contain 0,4083 silex, 0,175 magnesia, 0,1666 calx, 0,175 iron*. Here is a deficit of seven grains; but, what is most remarkable, he found no argill.

To discover which of those analyses approached nearest to truth, I made compounds of the ingredients given as the result of each; and in the proportion set forth in each. I found Weigleb's to give a glass similar to that of hornblende at a heat of 136_0; the calx of iron I employed was thoroughly oxygenated. My own compound gave also an equally just result when I used rust of iron; but then it got a much higher heat, viz. 156_0; when I used metallic iron instead of rust, I obtained only a slagg, and a great part of the iron separated itself from the earths.

Mr. Herman found black hornblende to contain 37 per cent. silex, 27 argill, 5 calx, 3 magnesia, and 25 iron. 5 Berl. Beob. 79.

This is the stone which, in conformity with the most eminent Swedish and French mineralogists, I denoted by the name of *hornstone* in my first treatise on mineralogy. The description I gave of it was such as candour could not mistake for that of petro-silex; but as I since found that writers, who apply this name to stones absolutely different from the sort of stones called petrosilices, extended it too far, as will presently be seen, I now, in conformity with Mr. Werner, apply it solely to those stones of the siliceous genus called *petrosilices;* since, however, it is still applied in various senses by writers of great merit, it may be proper to trace its origin. This name took its rise from common working miners; they observed that a sort of stone, of a dusky colour, was cut through with great difficulty by reason of a tenacity which resembled that of an horn or horse's hoof*; now, a horse's hoof, when in thin pieces has also a slight degree of transparency, this sort of stone they therefore called *hornstone*. Mineralogical writers observing this combination of properties not to meet together in the same stone, distinguished two sorts of hornstone, both of a dusky colour, one that had the semi-transparency, but not the tenacity of a hoof or horn, and another which resembled that substance only in colour and tenacity. This distinction I find in Henckel on the origin of stones†. Since that time the German writers in general have confined this name with some modification to stones of the first kind; that is, to the stones that all writers had indicated by the name of *petrosilices*, and the English in particular by that of *chort*. But the Swedes and French still apply it in the latter sense‡. The great weight of the stone called *hornblende* made the miners at first imagine it contained some metal, but finding none except iron they called it *blind*, in the same sense as the vulgar do nuts without a kernel. Hence the name *hornblende*.

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* 2 Chy. Ann. 1787, 15.

Wallerius describes what the Swedish writers called *hornstoncs*, thus:

" Their colour is always dark, their surface smooth, with a greasy lustre, their texture striated,

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* Vogel Mineral. p. 130.

† P. 400 of the French Translation.

‡ Wallerius.

ated, lamellar, fibrous, or sparry, easily scraped by a knife, presenting a greyish streak or powder, and an earthy smell while scraping or powdering; when heated they assume a brownish red colour and harden; in a stronger heat they melt into a black slagg, or compact glass. They do not effervesce with acids, though partially soluble by them in a boiling heat. Their specific gravity from 2,8 to 3,2."

This is almost an exact description of our hornblende. It is, he tells us, by the Swedes called *hornberg,* and by the French *roche de corne,* and by the Germans *hornfelstein.* Of this stone he distinguishes four varieties. 1st, That which is obscurely lamellar, which he calls *cornes solidus nitens durior.* 2nd, That which is of a slaty texture, which he calls *hornschiefer,* and is what I call *hornblende slate.* 3d, That which is of a sparry and striated texture, which he calls *hornblende,* or *strahl skimmer,* or *shorlblende, roche de corne strié.* And 4th, That which breaks into cubes, or rhomboids, which he calls *corneus trapezius* and *trap;* yet he tells us, that when broken in another direction it presents conchoidal surfaces. Here he evidently confounds hornblends with traps.

Mr. Saussure, though well aware of the double sense of the term *hornstone,* yet relying on the authority of Wallerius, and unwilling to multiply denominations, wished to restrain its signification to the species we here describe; but, in following Wallerius too implicitly, he unwarily comprehended stones under this name which are of a different species. Thus he reckons among corneous stones some which present no idea of crystallization, are destitute of lustre, and of an earthy texture; namely, traps*. Those whose fracture is lamellar or striated, he tells us, are by many called *hornblendes*; the specific gravity of these he found inferior to that of shorl, viz. 2,973, which certainly is not always the case. He thinks hardness the external character which chiefly distinguishes them from shorls, and therefore calls all those that are composed of rectangular laminæ, and which are hard enough to give fire with steel, shorls; but, assuredly, the distinction between them is grounded on more numerous differences, as will be seen in the article *shorl*; and the difference in their composition must be considerable, since they are completely fusible at 80°, and shorls only at 127°.

Romé de Lisle denotes the stone of which we here treat, sometimes by the name of *shorl en masse*, or continuous shorl, les shorls en masses informes lamelleuses désignés par les Allemands sous le nom de hornblendes†, sometimes by the name of *argillaceous shorl*‡; and under these denominations also he comprehends *hornblende slate*, and hornblendes of a striated or fibrous texture.

Mr. Saussure applies the term *shorl en masse* in another sense, which is not easily discovered, as the only mark by which he distinguishes it from other shorls is its hardness, intermediate between that of silex and limestone; and its specific gravity, which he does not determine; perhaps also he means (and this seems the most obvious sense of his expressions) that these criteria distinguish it from *other* stones; but surely not from trap or hornblende? with which, however, by treating them apart, he would seem to wish not to confound it.

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* 1 Saussure, 69. 75. † 2 Crystallogr. 309.
‡ Ibid. p. 338, 348, 377, 425.

The argillaceous smell, by which Mr. Saussure and I myself formerly sought to distinguish this species of stone, is a very fallacious test; for, I have since found the same smell emitted by various traps after breathing on them, by serpentines, and even earthy limestones. Mr. Desmaretz, in the Mem. of Paris, 1773, denotes hornblende by the names of *shorles en grandes masses*, *black basalt*, *gabbro en masses confuses*, indicating shorls in general by the name *gabbro*. This last appellation was grounded on a mistake, since detected by Mr. Saussure.

Baron Born, in the description of Miss Raab's Mineral Cabinet, calls our stone *foliated shorl*, and under the same name comprehends also Thumerstein, though its composition, as well as external characters, are very unlike. With him Mr. Gerhard, of Berlin, also agrees; because both shorls and hornblendes are fusible per se into a black slagg; but so also are basalts; must they also be confounded with the former? I should imagine that, until we are much better acquainted with the composition and formation of minerals than we are at present, they can scarce be too minutely distinguished from each other. Wallerius was very pardonable for confounding many which were little known at the time he wrote; but to take him as a guide, after the numerous illustrations and distinctions furnished by Mr. Werner, seems to savour of prejudice.

Mr. Lenz mentions some crystallizations of hornblende distinct and different from basaltic hornblende; but neither Werner's Catalogue of Mr. Pabst's fossils, nor Leske's, mention any; hence I should suspect it a mistake.

8th Species.—Basaltine. Basaltic Hornblende, or Crystallized Hornblende of Werner. Shorl Spath of Ferber. Shorl prismatique hexagone of Saussure.—Colour, black, or greenish black, or dark green, or yellowish green.

It is mostly found in basalts, wacken, and lava; in the former it is generally black, or greenish black; in the latter, of the lighter hue*; hence I have called it basaltine. Mr. Saussure has also found it in granite †. It is found crystallized in rhomboidal, hexahædral, or octohædral short thick prisms generally mutilated, terminated by flatted three-planed pyramids. The crystals not seamed or sulcated.

Lustre, 3. Transparency, in very thin pieces, 1; and transmits a reddish yellow colour.

Fracture, foliated, if broken in the direction of the luminæ; its cross fracture uneven, and often conchoidal; but in that found in lavas the foliated texture is more difficultly discernible.

Hardness from 9 to 10. Brittle. Specific gravity 3,333, by my trial.

It gives a white streak.

At 119° it melts into a glass partly grey, and partly greenish black.

This species, which the French, Swedish, and Italian mineralogists have indicated by the name of shorl, or hexangular shorl, seems to be that which was analyzed by Mr. Bergman under the appellation of black shorl of St. Albano,

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* 4 Helvet. Magaz. 242, 251.

† 1 Saussure, 67.

bano, deemed an ancient extinct volcano, near Veletri, in the neighbourhood of Rome; he found it to contain 0,58 silex, 0,27 argill, 0,04 calx, 0,01 magnesia, and 0,09 iron. 3 Bergm. 207.

The degree of hardness I have attributed to this stone is such as I have observed in the specimen of Leske, O. 1043, and in Voight's Collection, No. 46. It is said, however, that some are softer. 2 Bergm. Journ. 1788, p. 509. 1 Nose Orogr. Briefe 119, 120. Hence this last writer, a man of great sagacity, and who has bestowed much attention to this sort of stone, thinks that the softer kinds should alone be called *hornblende crystals*, and the harder sorts rather *garnets*, which often agree with them in colour and form; but I think the much greater fusibility of basaltines, whether hard or soft, sufficiently distinguishes them from garnets.

The great lustre of these stones, when set in basalts, frequently occasions them to be taken for mica; their quadrangular shape, however, may always serve to discriminate them.

9th Species.—Resplendent Hornblende.—Of this there are two varieties.

1st Variety.—Labradore Hornblende.—Colour, in most directions, greyish black, or blackish grey; but in other positions it reflects a strong iron grey, either singly or mixed with dark copper red.

Lustre in the first case, 0; in the second, 3 or 4, and metallic. Transparency, 0.

Fracture, mostly curved foliated.

Hardness from 8 to 9; some are said to be softer. Specific gravity by my trial, from 3,35, to 3,434.

2nd Variety.—Schiller Spar.—Colour, yellowish, leek or apple green, or golden yellow, reflecting a white, grey, or yellow, in certain situations, and some even in all situations.

Generally found shooting out of serpentine.

Lustre, metallic, 4. Transparency, in thin pieces, 1.

Fracture, foliated. Hardness from 8 to 9, often only 7. Specific gravity by my trial, 2,882; it would have been higher if I could have separated the serpentine perfectly.

At 141° a part of the specimen Leske, O. 1041, hardened and formed a porcelain mass.

I had not a sufficient quantity of the first variety to examine its fusibility; but the infusibility at so high a heat of this variety at least, shews it to be specifically different from common hornblende. By the analysis of Mr. Gmelin, it contains 0,437 silex, 0,179 argill, 0,112 magnesia, and 0,237 iron. 1 Bergbau. 92.

10th Species.—Shistose Hornblende. Hornblende Slate. Hornblende Schiefer of Werner. Roche de Corne feuilletée. 1 *Sauss.* § 166. p. 119.—Colour, greyish, or greenish black, or dark bluish grey, or greyish blue; seldom dark leek green.

Found in large masses.

Lustre, 2, sometimes silky. Transparency, 0, rarely 1.

Fracture, in the great slaty; but of the slates themselves, striated, generally straight and interwoven, rarely diverging.

It gives a greenish grey streak.

Hardness from 7 to 9, difficultly frangible.

Specific gravity from 2,909 to 3,155, by my trial.

Heated to redness it becomes sometimes reddish grey, sometimes reddish brown. At 80° I melted the specimen Leske, O. 1037, into a black compact glass; a sure sign that it is not of volcanic origin. The specimen of Leske, O. 1038, melted at 108° into a greyish black, somewhat porous slagg, whose specific gravity was 2,308 from the number of air holes. The specimen Leske, G. 135, melted at 130° into a brownish black, almost compact glass. Hence we need not be surprised that it was often mistaken for trap (called basalt). Voight Prack. Gebirg § 21.

11*th Species.*——*Wacken.*——Colour, dark greenish, or blackish, or yellowish, or reddish grey, or greyish black, or liver brown.

Found in considerable masses.

Lustre, 0. Transparency, 0. It feels merely as a sand-stone.

Fracture, even, earthy; seldom uneven, and then fine-grained *.

Fragments, 2. It never presents separate distinct concretions.

Hardness from 6 to 9†. Specific gravity by my trials, from 2,535 to 2,893; that of the specimen Leske, O. 1047, is 2,535; that of O. 1045, is 2,622; and that of O. 1046, is 2,893.

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* According to Hoffman, 2 Bergm. Journ. 1788, its fracture is *uneven*, and fine-grained, approaching the splintery. According to Kärsten, it is commonly *even*, seldom *uneven*. 3 Helvet. Mag. 234.

† Nose also remarked, that it sometimes gives fire with steel. 1 Nose, 148.

This last is blackish green, gives an earthy smell, and pounds tough, so that it would undoubtedly pass for a *pierre de corne* among the French. Mr. Succow found that of a wacken, near Frankfort, 2,576. 2 Chy. An. 1786, 430.

The greenish grey, Leske, O. 1045, melted at 124° into a yellowish grey, very porous, opaque slagg; that of Leske, O. 1046, melted at 130° into a true compact black glass; and so did that of Leske, O. 1047. Hence these two last do not seem truly to belong to this species.

It withers by exposure to the atmosphere, and then becomes more grey.

Its transition is into trap or basalt.

It must not be confounded with the Grauwaken of the Hartz, which is a very different species.

This stone has not as yet been analyzed; but most probably consists of silex, argill, calx, in a fusible proportion, and iron in a smaller proportion than the foregoing, and also than traps or basalts.

It frequently contains black mica and basaltine, but never olivin.

12th Species.—Mullen Stone.—Colour, ash, or bluish grey, often mixed with ochry yellow, from the decomposition of its ferruginous parts.

Found in considerable masses, and frequently contains basaltine; it also often inclines to a regular form mostly quadrangular, like basalt. Nose 1, 250.

Surface, where exposed to the air and moisture, covered with a greyish white rind, sometimes slightly ochry.

Lustre, 0, except some shining particles of basaltine. Transparency, 0.

Fracture, uneven, and fine splintery.

Hardness, from 7 to 9. Specific gravity from 2,6 to 2,738.

It frequently occurs in our Northern counties, and is by the pump-sinkers called *mullen*; it is evidently the grey basalt of Ferber, mentioned is Leske's cabinet, S. 351. It seems to be the third variety of trap, mentioned by Mr. Faujas, p. 88.

At 130° it melts into a black compact glass.

See also the specimen Leske, S. 95.

13th Species.—Kragg-Stone. Leske, S. 661, (*and* 1695, *Q.*)—Colour, greyish red, or reddish grey; exceeding porous, the pores often filled with various crystallizations.

Lustre, 0. Transparency, 0.

Fracture, uneven and earthy. Fragments 2. Hardness from 5 to 7. Specific gravity 2,314.

Feels rough and harsh, gives a yellowish grey streak.

At 138° it melted into a reddish brown porcelain mass.

It is found in the neighbourhood of Belfast, and there called kragg-stone; it resembles the stone mentioned by Leske, S. 661, by him called a basalt. It seems also to be that mentioned by Mr. Faujas as the 5th variety of trap, p. 91.

This stone is often mixed with globules of magnetic iron stone, which adds considerably to its specific weight, as in the specimen Leske, S. 1233, whose specific gravity amounts to 2,910.

These three species, viz. wacken, mullen, and kragg, have been by most writers confounded with trap, but their colour, specific gravity, and fusibility, shew they must be distinguished.

14*th Species.*—*Trap.*—Of this I distinguish two families; the common, or amorphous, and the figurate.

1*st Family.*—*Common Trap, Basalt of Werner.*—Its most usual colours are the greyish or bluish, or purplish black; more rarely blackish, or reddish brown (as in the basis of mandelstein or toadstone) or greenish grey; traps of the last colours seem to me to be mixed with other species.

Found in large masses, and frequently containing basaltine, quartz, calcareous spar, calcedony, zeolite, hyalite, felspar, (trap porphyry) and olivin.

Hence it is frequently found porous, cellular, and cavernous, from the decomposition and falling out of these stones.

Externally it has frequently a brown or reddish brown rind, from decomposition.

Lustre, 0; or from shining particles of basaltine dispersed through it, 1; see Leske, S. 102, 835. Transparency, 0.

Fracture earthy or fine splintery, often uneven. Fragments 2.3, often tending to a quadrangular form.

It often presents small or coarse-grained distinct granular concretions.

Hardness from 8 to 9, and difficultly broken, except when in a state of decomposition, and then often only 5 or 6. Specific gravity when sound lies between 2,78 and 3,021 exclusively, by my trials; the specimen that exhibited the last is that in Leske, S. 1695, whose colour is reddish brown, and has several red grains in it. The specimen Leske 1223, which is greyish black, has its specific gravity 2,728, but then it is not pure; for, at 148°, it melted only into a somewhat porous liver-brown mass, between a porcelain and an enamel. The specimen, Leske, G. 264, which is bluish or greenish black, has its specific gravity, 3,478; but then, as Mr. Kärsten observes, it contains a quantity of magnetic iron stone. The specific gravity of the stone called trap by Mr. Brisson, is 2,745, and of that which he calls basalt of an irregular form or touchstone, 2,4153; but this most probably is that sort of siliceous schistus, called lydian stone, of which hereafter. The specific gravity of this stone must undoubtedly vary with its state and degree of decomposition, and with the quantity and sort of foreign ingredients contained in it, as well as the proportion of its own constituent parts; but we may state that of the purest at a medium 2,87 or 2,88.

By exposure to the influences of the atmosphere, and often by mere moisture, this stone is frequently decomposed, and invested with a brown, yellowish, or reddish brown rind.

Exposed to a heat of from 120° to 130° it melts into a black compact glass.

According to the analysis of Mr. Bergman, the trap of the mountain Hunneberg, in West Gothland, contains 0,50 silex, 0,15 argill, 0,08 aërated calx, 0,02 magnesia, 0,25 iron, though in the dry way it would yield but 0,10 of iron. 3 Bergm. 213. The magnesia is evidently of little importance, but we may observe that the quantity of iron exceeds that of argill, and is very slightly oxygenated. It is probable the iron is sometimes mixed with manganese and sometimes with nickel, from which last the green colour may probably originate, which is sometimes

times observed in traps, though most commonly it proceeds from the iron itself.

In England, three varieties of trap have been observed; namely, toad-stone, or rather its basis; rowley ragg; and whin-stone. Mandelstein.

Toad-stone is of a dark brownish grey colour, abounding with cavities filled with crystallized spar, which, with the brown colour of the basis, gives the whole the appearance, from which it derives its name. The cavities, from the destruction or decomposition of the spar (originating from the iron contained in it) are frequently empty. The specific gravity of a toadstone, free from calcareous matter, was found by Dr. Watson, 2,921; and of another 2,85; but that of another, in a state of decay, 2,68; and of one still more decayed, 2,558. By the analysis of Dr. Withering, this stone contains 0,68 silex, 0,14 argill, 0,07 mild calx, and 0,16 calciform iron.

Rowley ragg, or *Ferrilite,* is of a black colour, with numerous white dots, and black lamellæ of basaltine, which give it a dark brownish grey appearance. It is found in large masses, which affect a rhomboidal form; some of these inclose rounded pebbles of the same substance. By exposure to the air it acquires an ochry crust. Internally it hath some lustre from a number of minute shining particles. Fracture, nearly even, or fine splintery, yet often inclining to the flat conchoidal. Opaque. Hardness 9. Specific gravity 2,748, by my trial.

Heated in an open fire it becomes magnetic, and loses about 3 per cent. of its weight. It does not redden; but at 98° melts into a somewhat

what porous black mass, partly porcelain, and partly an enamel.

According to the analysis of Dr. Withering, it contains 0,475 silex, 0,325 argill, 0,20 calx of iron. Here we may observe, 1st, that it contains no calx; 2nd, that it contains less iron than argill; and, 3d, that the iron is in a calciform state. In these respects then it differs from many traps, and from basalts; hence I call it *ferrilite*.

Whin-stone is a name used in England, Scotland, and the North of Ireland. It is of a blue, or greyish black colour, whose hardness is from 8 to 9. Specific gravity from 2,4 to 2,88, is often a *trap*. It is found in detached fragments, or forming dykes in mines: of these a curious account, by Mr. Mills, may be seen in the Phil. Trans. for 1790, p. 73.

The basis of the cellular stone, called amygdaloid, the mandelstein of the Germans, is also frequently a trap, generally of a greyish, blackish or reddish brown, or yellowish black, or greenish grey; and has its holes filled with quartz, spar, or calcedony, often with bole, &c. or empty; and the sides of an ochry, or bluish grey colour, derived from the stones that fell out of them. That mentioned in Leske, G. 296, had its specific gravity 2,443, and gives a reddish streak. It melted at 130° into a black, compact glass; that in Leske, G. 300 had its specific gravity 2,354, gives a white streak, and melts into a mass similar to the former. The hardness of both is 8.

It is the porosity of this stone that renders it so light.

Its transitions, and those of kragg and mullen stones that are nearly allied to it, are into each other, or into wacken, or argillaceous marl, or sand-stone, or shistose porphyry, or amygdaloid.

Such of these stones as are specifically lighter than 2,78 seem to contain wacken, or some other of those species that border on the genuine traps.

2nd Family.—Figurate Trap, Basalt. Basalt of Werner.—Colour, greyish black, sometimes bluish, or brownish black; when withered, the surface is greyish, or reddish brown.

Found in considerable masses.

Lustre, properly, 0; but from some shining particles intermixed with it, 1. Transparency, 0; yet sometimes in very thin pieces, 1.

Fracture, compact, mostly fine splintery; sometimes approaching to the even, or flat conchoidal. 1 Bergm. J. 1792, 300. Fragments, 2.

Generally of a columnar form, straight or curved, perpendicular or inclined, rarely parallel; and when erect generally diverging beneath; their diameter from three inches to three feet, sometimes with transverse semispherical joints, in which the convex part of one is inserted in the concavity of the other; the angle of the concave often prolongated where it receives the convex; these joints are called *articulations*. The forms of the columns are pentangular, hexangular, or octangular, more rarely triangular, or quadrangular. Sometimes the columns are irregular.

It is also sometimes found in rounded thick laminar masses, either spherical or compressed, and lenticular, sometimes of a tabular form; both these, and the columns when broken, present thick laminar concretions incrusted with ochre.

Hardness, from 8 to 9. The pillars of the Giant's Causeway, exposed to the roughest sea for more than 20 centuries, have their angles as perfect as those more distant from it; a complete refutation of Buffon's Theory.

Specific gravity of some basalts 3,000, according to Bergman; of that of the Giant's Causeway, according to Brisson, 2,864; or according to Dr. Hamilton, 2,900; of that of Fairhead, according to Mr, Mills, 2,95. He mentions some of less density, but they are probably traps; for, though both are of the same species, yet basalt is known to have most commonly a smaller and closer grain. Mr. Succow found a basalt from Fulda 3,123, but this was in the temperature of 65°, 75. I found that of another from Saxony, of a pentagonal form, 2,979.

It is sometimes magnetic, sometimes not; Baron Veltheim tells us, that among 100 specimens of the basalt of Stolpe, he scarcely met one that moved the magnetic needle. 1 Chy. An. 1788, 412.

Frequently sonorous when struck.

Gives a grey streak.

When heated reddens. I melted that of Saxony into a black glass at 100°, so compact that its specific gravity was still 2,859; at 130° its glass is still more compact.

According to Mr. Bergman, it consists of the same principles as trap, and in the same proportion. It almost always contains particles of basaltine, sometimes also hornblende, the German basalts contain also olivins; but these last are not found in the Irish; also, though more rarely, felspar, quartz, zeolytes, shorl, and spar. Micas are scarce ever yet found in it, though sometimes upon it. Wacken, on the contrary, never exhibits olivins.

15th Species.—Calp, or black Quarry Stone of Dublin.—Colour, bluish black, or dark greyish blue, variously intersected with veins of white calcareous spar, and often invested with the same.

Found in large masses.

Lustre, 0, except a few shining particles of spar. Transparency, 0.

Fracture, exceeding fine splintery, passing into the even, and sometimes into the imperfect, conchoidal. Fragments, 2. In the direction of its strata it easily splits into large flaggs.

Hardness, from 6 to 7. Specific gravity from 2,646 to 2,70.

It gives a white streak.

It effervesces with mineral acids.

Gives an earthy smell when breathed on.

At 130° melts into a black compact glass.

Contains 50 per cent. mild calx, the remainder silex, argill, and iron. The argill seems, however, to preponderate.

It seems to be the calcareous trap of Lasius, Hartz, 170; at least, this agrees with its colour, specific gravity, and in containing calcareous matter.

16th Species.—Argillite, or Argillaceous Shistus or Slate.—Thon Schiefer of Werner *. —Colours, the most usual are bluish, greenish, or blackish grey, or the greyish blue, or greyish green, or greyish, bluish, or reddish purple.

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* Werner's Cronsted 208. 3 Helvet. Magaz. 185 per Kärsten. Leake, Museum, &c.

More rare are the yellowish grey, brownish red, reddish brown, greyish black, bluish black, or mountain green. Sometimes with stripes or spots of a darker colour.

Found in considerable strata.

Lustre seldom 0, oftener 1, from some dispersed glimmering particles, frequently 2, and silky, rarely 3. Transparency, 0.1.

Fracture, slaty, commonly straight, sometimes curved, or undulating; sometimes thick, frequently thin, more or less difficultly separable; sometimes approaching to the foliated. Fragments, 2, frequently tabular; sometimes long splintery, rarely trapezoidal, or rhomboidal.

Hardness, from 5 to 8. Specific gravity from 2,67 to 2,88; but generally from 2,7 to 2,8. Lasius mentions one of a pearl grey colour, whose specific gravity is but 2,500; Hartz, 109. The heavier contain an excess of iron.

It gives a white or grey streak, sometimes a reddish grey.

It does not adhere to the tongue

It does not stain, yet Lasius mentions one so soft as to leave a white line, on harder stones. Ibid.

It is composed of silex, argill, calx, magnesia, and iron, with some bituminous particles; the proportions nearly in the order I have mentioned, when the mean of all the varieties is considered; but in the different varieties, the proportion varies considerably; and hence the numerous varieties of this species: with these, mica or talc is often intimately incorporated.

Its transitions are into sand-stone, siliceous shistus, jasper, horn-stone, grau-wacken, syenite, shistose hornblende, shistose porphyry.

Very commonly it imbibes water, but different varieties absorb it in various proportions.

It sometimes bears impressions of vegetables, sometimes of shells.

It differs from slate-clay, in the form of its surface, hardness, specific gravity, relation to water, and inadhesion to the tongue, as well as in composition, containing more magnesia and iron.

The curved slaty argillites have their cross fracture hackly, and opaque.

1st Variety.—Anglesey Slate.—Purple, or reddish purple. Internal lustre 1. Opaque. Hardness, from 7 to 8. Specific gravity, from 2,84 to 2,876. It does not imbibe water, gives a reddish white streak. Does not effervesce with acids, unless powdered, and then weakly. Gives a greenish colour to nitrous acid after standing some days. Becomes brownish red when heated. Slightly detonates with nitre. Melts into a black spongy mass. Contains 0,38 silex, 0,26 argill, 0,08 magnesia, 0,04 calx, 0,14 iron perhaps mixed with nickel, or perhaps the green colour of the nitrous acid may proceed from the bituminous substance contained within it; this seems most probable.

2nd Variety.—Westmoreland Slate.—Many sorts are found in that county; but that which passes for the best has its colour, bluish grey; when moist, greenish grey. Lustre, silky, 2, opaque. Hardness, 6. Specific gravity, 2,752; gives a white streak; does not imbibe water; slightly effervesces with acids; by heat becomes reddish brown; and at last, melts into an opaque glossy slagg.

The pale grey slate of Westmoreland have their specific gravity 2,732, the purple 2,797, according to Dr. Watson. Some of the former afforded him a strong lime-water after calcination. The silky gloss intimates the presence of magnesia.

Ash grey Slate of France.

According to Brisson, its specific gravity before it absorbs water is 2,6718, and after absorption 2,6905; it consequently absorbs $\frac{1}{141}$ of its weight of water. Of other slates, used for roofs, he found the specific gravity before absorption 2,8535, and after absorption 2,8592. The best are those that absorb least.

3d Variety.—Killas.—Pale bluish grey, or red, or whitish yellow. Lustre, silky, opaque. Its surface undulated. Fracture, long splintery, and imperfectly slaty. Hardness, from 4 to 5; the whitish yellow still softer, but that of a dark grey, I am informed, is 9. The specific gravity of the bluish grey I found in different specimens from 2,63 to 2,666; it contained by my analysis 0,60 silex, 0,25 argill, 0,09 magnesia, and 0,06 iron, and some petrol or bitumen, as appeared by the greenish hue which it gave to the nitrous acid. As it wants calx it can scarce be deemed a true argillite.

4th Variety.—Argillite of Ditters Back.—Leske, O. 954.—Greyish black. Lustre, strong and silky. Opaque. Fracture, undulatingly slaty, which gives it a striated appearance. Fragments, tending to the rhomboidal. Hardness, 6. Specific gravity, 2,727. At 140° it melted into a yellowish green porous glass.

5th Variety.—Grapholite.—Black, or bluish black.

black Hath scarce any lustre. Opaque. Splits easily into smooth plates. Its cross fracture long splintery. *Gives a white streak, and is generally used to write upon.* Hardness, 5. Specific gravity, 2,701. When powdered it effervesces with acids.

17th Species.—Novaculite. Turkey Hone. Shistus Coticularis of Wallerius. Pierre de Rasoir. Wetzstein of Werner.—Colour, greenish grey, or inclining to mountain green, or pale greyish yellow; rarely spotted.

Found in large masses.

Lustre, 0.1. Transparency, 1 or 1,5.

Fracture, slaty, but inclining strongly to the splintery; sometimes also to the conchoidal, and earthy.

Hardness, from 7 to 8, rarely 9. Specific gravity from 2,609 to 2,955, by my trial. According to Brisson, hone-stones for razors, of a dirty white, absorb water; before absorption the specific gravity of one of them was 2,8763, and after absorption 2,8830; so that it absorbed $\frac{1}{414}$ of its weight. He mentions another whose specific gravity was 3,1398, whose colour was black and white.

Some feel somewhat greasy. Effervesce slightly with acids; and some not.

There are other stones also used for hones, as some argillites and sand-stones; these last form the coarser whet-stones.

Some at least are decomposed by exposure to the atmosphere, and form a white earth.

From all this it appears that this species contains many varieties of composition.

I shall here mention a few of those varieties I have met with.

1st, That of Leske, O. 976, whose colour is mountain green. Hardness, 7. Specific gravity, 2,722, and does not effervesce with acids, melted at 120° into a somewhat porous hard greyish black, porcelain mass, whose surface was vitrified.

2nd, Another which I bought in London: could not hear whence it came; but it is used for setting razors; was of a greyish yellow colour. Lustre, 0. Transparency, 1,5. Fracture splintery. Fragments, 1. Hardness, from 7 to 8. Specific gravity, 2,609. And effervesces very slightly with acids. Heated to 120°, it hardened sufficiently to give fire with steel, and grew perfectly white, the outside had a glazed semivitrified appearance, but the inside a more distinct unvitrified grain.

3d, Another from the same shop, whose colour was Isabella yellow. Lustre, 0. Transparency, scarcely 1. Hardness, from 7 to 8. Specific gravity, 2,955. Did not effervesce with acids. At 120° it melted into a yellow porous enamel.

CHAP. X.

SILICEOUS GENUS.

1st Species.—Mountain Crystal and Quartz.

These form two families, the only difference being in their fracture and transparency.

1st Family.—Mountain or Rock Crystal.—

When purest it is colourless, but it is also found greyish, and yellowish white, or pale yellow, otherwise called *citrine,* and impure topaz; or pale or dark brown, or brown falling into black, then called *morion,* or, though very rarely, pale rose red, or white, or brown, and iridescent.

Its lustre glassy, 3. Transparency, 4. It causes a double refraction.

The forms of its crystals are various, the most usual is that of hexangular prisms, surmounted with hexagonal pyramids on one or both ends, the angles of the prism corresponding with those of the pyramid; sometimes the pyramids are joined base to base, and frequently it exhibits but one pyramid, or a prism without a pyramid. The prisms are generally seamed perpendicularly to their axis, the pyramids scarce ever. For other forms I must refer to Mr. de Lisle.

Fragments rounded by rolling in water are also frequent.

Its fracture is *conchoidal,* but frequently so flatly as to resemble the foliated.

Its fragments, 4 or 3. Its hardness, 11. Its specific gravity, 2,653, when colourless; that the red 2,67.

2nd Family.—Quartz.—Its colours are various, white, grey, yellowish, reddish, or greenish, greenish white, or yellowish, bluish, or pearl grey, or yellow, or swarthy brown, or pale or blood red.

Its external lustre casual, the internal, 3, 2, or 1. Its transparency, 2, 3, rarely 1.

Commonly amorphous, frequently crystallized, as mountain crystal. The prisms have sometimes been found crooked. N. Act. Petrop. 1785, p. 265. Cubic crystals of quartz have also been discovered. 1 Leske, O. 418 *. Also in quadrangular plates heaped together; and frequently in the form of sand, and sometimes in columnar distinct concretions adhering together or to each other.

Its fracture fine or coarse *splintery*, very rarely straight fibrous. The splinters are sometimes so gross and rounded as to resemble the conchoidal form.

Its fragments, 3, indeterminate; yet sometimes rhomboidal. Leske, O. 429.

Its hardness, 10. Brittle. Specific gravity from 2,64 to 2,67.

It does not wither by exposure to the air. Nor yield to any acid but the sparry.

When heated to redness it loses its transparency, which mountain crystal does not, and generally decrepitates. It is infusible *per se* in any heat but that of pure air, which barely softens it. But it yields to alkalis with effervescence; to borax slowly and without any.

Its transitions are into horn-stone, flint, carnelian, opal, calcedony, siliceous shistus and sandstone.

By the nicest test that could be employed, Mr. Brugman could not discover the smallest degree of magnetism in mountain crystal †. Mr. Bergman in one specimen found 6 per cent. of argill, and 1 of calx; but Mr. Meyer in another found only 2 per cent. of argill ‡; and Mr. Gerhard frequently found none at all.

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* It has been found also in quadrangular prisms. Ferber Briefe, 41.

† De Magnetismo, p. 73, 101.

‡ 1 Cby. An. 1785, p. 63.

By long digestion in acids, both he and Mr. Dorthes imagine they discovered some traces of iron. Yet as they employed the Prussian alkali, which by long digestion in acids always betrays its own ferruginous contents, I think this experiment inconclusive. The coloured crystals, however, undoubtedly contain some metallic particles.

Varieties of this Species.—*1st Variety. Glassy,* otherwise called fat quartz, of a greyish or bluish white, or red, yellow, brown, bluish or violet, or brown or black. Its lustre that of grease, more or less semi-transparent. Its fracture gross splintery and thence bordering on the conchoidal, on that account it feels smooth, and as if it were greasy. Its hardness, 10. Its specific gravity, 2,6459.

2nd Variety. Arid, or meagre quartz. White, grey, brown, or greenish, has less lustre than the former, and feels more harsh; its fracture more splintery. Its specific gravity, 2,640.

3d Variety. Lamellar, by some called foliated, or sparry quartz, not from its fracture, but from its form, as it consists of plates either superimposed on each other, or more generally placed at various angles with each other, and thence it is called *cellular,* sometimes also in the form of a cock's comb, and thence called *cristated.* According to Baron Born, those found in Hungary are frequently partially soluble in nitrous acid, without effervescence, as they contain a considerable portion of calx, and sometimes also of barytes. 1 Raab. 48.

4th Variety. Stalactitic in the form of solid or hollow cones, or in that of roses, cauliflowers, grapes, &c.

5th Variety. Fibrous, this is exceeding rare.

6th Variety. Granular, consisting of grains compacted together, often resembles sand-stone, sometimes close and sometimes loose. Mr. Ferber mentions some of this kind that resemble pumice, being so light as to float on water; whole mountains he says are formed of it. N. Act. Petrop. 1785, p. 265. Some are cristated, and often contain calcareous earth.

Of the granular variety the most remarkable is that called aventurine, which contains some mica interspersed betwixt its grains, and hence reflects a metallic lustre. Of which Baron Born mentions five sorts. 1st, The white and semi-transparent, with lamellæ, that reflect a silvery lustre. 2d, The red or brownish red, which reflects a gold colour. 3d, The grey. 4th, The green, both of which reflect a silvery colour. 5th, The black, reflecting a golden lustre.

7th Variety. Rosy red quartz, found in Bohemia and Bavaria; is distinguished by its lustre, transparency, and fracture, which is imperfectly conchoidal. It is said to derive its colour from manganese.

8th Variety. Honey yellow, otherwise called *citrine,* or impure topaz; in Carinthia this is found in pellucid hexahædral prisms, and perfectly transparent; but near Catharinenberg, in Siberia, Mr. Bindheim found a crystal of this sort with very singular properties; in form and transparency it agreed with that of Carinthia, but its hardness was, 12. Its specific gravity, 2,755*. When heated it attracted ashes and other light bodies like tourmaline; it even became electric by friction, and when so, attracted fine iron filings. It was infusible *per se*, nor had borax, or microcosmic salt any effect on it, but mineral alkali fused it into an opaque opalescent mass without effervescence. By his experiments it appears to consist chiefly of silex, with a few particles of calx of iron and lime. 2 Berl. Beob. 256.

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* The book says 1,755, but I believe this must be a mistake of the press, otherwise the author would have noticed a circumstance so remarkable.

2nd Species.—Amethyst.—Its most usual colour is *violet blue* of different degrees of intensity, also milk white, grey, and very rarely olive or grass green; often striped with two colours.

Its shape is generally that of hexahædral pyramids, yet often occurs in blunt-edged pieces.

Its internal lustre, sometimes strong, sometimes weak, and very weak.

Its transparency, 2 to 4. It causes a double refraction.

When its lustre is strong, its fracture is conchoidal, when weaker splintery, when weakest intermediate between the splintery and the coarse diverging fibrous.

It often presents irregularly columnar distinct concretions approaching to the granular, whose planes are obliquely seamed across.

Its fragments, 3. Indeterminate.

Its hardness, 10 or 11. Its specific gravity, from 2,651 to 2,657.

It is infusible *per se* at 160°, but loses its colour in a strong heat and becomes shivery; it is said to derive it from manganese. By the heat of pure air, it is reduced to an enamel.

Mr. Achard attributes to 100 parts of this stone 60 of argill, 30 of silex, 8,22 of lime, and 1,66 of iron*. Yet as its external characters, and particularly its specific gravity is so low, I think it should be placed immediately after the quartz, at least until the analysis be repeated, for its infusibility render this somewhat suspicious.

3d Species.—Emerald.—Its colour is from the perfect to the pale grass green.

Its lustre, 3 to 4. Its transparency, 3.4.2. Gives a double refraction.

Its shape hexangular prisms, truncated at the sides or angles.

Its fracture conchoidal inclining to the uneven. Its fragments, 3. Indeterminate.

Its hardness, 12. Its specific gravity 2,775.

Heated to 120°, it becomes blue, but recovers its colour when cold; at 150° it melts *per se* into an opaque discoloured mass.

It is scarcely fused by mineral alkali, rather better by microcosmic salt, and tolerably well by borax, when exposed to the blow-pipe.

One hundred parts of it contain, by Bergman, 60 argill, 24 silex, 8 calx, and 6 of iron; and by Achard 60 argill, 21,66 silex, 8,33 calx, and 5 of iron. Neither of these results is improbable. Mr Quist observed, that the addition of lime renders emeralds more fusible, which is very consistent with its properties and composition.

Emeralds are now found only in Peru; the Brasilian are in reality actinolites.

This stone cannot be placed among the precious, by reason of its low specific gravity and double refractive power; and, as it agrees in most respects with crystal, it may as justly be placed in the same class with it as amethyst is by many mineralogists; the only reason that could prevent it is the fusibility of the emerald, which induces me to separate them.

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* Quoted in 6 Leonhardi, 398.

*4th Species.—Berryll**. *Aigue Marine of many.*—Its colour is greyish green, often verging on the apple green, more rarely bluish green. Its internal lustre is variable. Transparency, 2.3.4.

Crystallized in equiangular hexahædral prisms longitudinally streaked.

Its longitudinal fracture is rather conchoidal; its cross really foliated, though it appears only uneven.

Its hardness is at least 12. Its specific gravity from 2,65 to 2,722.

It decrepitates when heated, and generally is discoloured; but does not melt in a heat of 150°. Mineral alkalis affect it most, borax very little, and microcosmic salt scarce at all.

It becomes electric by friction; but one of its poles is attractive whilst the other is repulsive.

According to Mr. Bindheim's analysis, 100 parts of it contain 64 of silex, 24 argill, 8 calx, and 1,66 iron.

It seems also to be the stone which Mr. Heyer analyzed under the name of Siberian aigue marine, and in which he found 0,67 silex, 0,32 argill, 0,01 calx, and 0,002 of iron†.

Mr. Herman, 61 silex, 29 argill, 2 calx, and one-third iron, 7 parts lost. 1 Chy. An. 1792, p. 295.

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* 1 Berg. Journ. 1788, p. 253. 1 Chy. An. 1790, p. 491. 2 Lempe Magaz. p. 60.

† Berl. Beob. p. 154.

5th *Species.—Prasium.*—Generally of a dark brownish, sometimes yellowish green.

Its lustre, 2. Transparency, 2.

It is found either in irregular masses, or crystallized in hexahædral pyramids, or small hexahædral tables, superimposed one on the other, and forming hexahædral prisms, sometimes in slender needle like crystals.

Its fracture, coarse splintery. Its fragments sharp.

Its hardness, 10. Its specific gravity, 2,580.

It is capable of a fine polish, but, after some time, is said to become turbid.

It seems to consist of a mixture of quartz, and shoerlaceous actinolite, both are even sometimes distinguishable

6th *Species.—1st Family.—Oriental Ruby.*—Its colour is carmine red, sometimes verging to violet, or intermediate between carmine and hyacinth red; but the same stone is in various parts, sometimes red and white, or red and blue, and thence called sapphire ruby, or orange red, by some called vermeille or rubicelle.

It is found crystallized in elongated hexagonal pyramids joined to, and opposed base to base; its size seldom an inch. Its lustre, 3.4 Transparency, 3.4.

Its fracture, foliated. Its fragments, 3.

Its hardness, 17. Its specific gravity, 4,288

It retains its colour and is infusible in a heat of 170°, somewhat discoloured and barely softened by the heat of pure air.

When finely powdered, borax melts it though with difficulty into a greenish glass, it yields also to microcosmic salt, but not to fixed alkalis.

By Mr. Bergman's analysis, 100 parts of the vermeille kind contains 40 argill, 39 silex, 10 aërated calx, and 10 of iron.

By that of Mr. Achard, 41,66 silex, 36,66 argill, 8,33 calx, 10,83 of iron.

However, I found a compound of 39 parts silex, 40 argill, 10 aërated calx, and 10 oxygenated calx of iron, to melt at 140°, into a greyish black porous slagg. I therefore believe that the proportion of calx set forth in these analyses is too great. The high specific gravity of the stone prevents me from judging that of the iron too high.

2nd Family.—Oriental Topaz.—Its colour golden yellow.

Lustre, 3, 4. Transparency, 4. Gives a single refraction.

Its shape as that of the ruby.

Its fracture, foliated. Fragments, 3.

Hardness, 15. Specific gravity, 4,0106.

It is infusible *per se*, and loses its colour, only in a very high degree of heat. Resists alkaline fluxes, and yields only to borax and microcosmic salt, with which it yields a clear glass.

3d Family.—Oriental Sapphire.—Its colour, Berlin blue, but often decreases so much in intensity as to become almost white, and then called *lux sapphire*.

Its internal lustre, 3 or 4. Transparency, 3.4.2. Causes a single refraction.

It is found crystallized in the same form as the preceding families, and often in rounded masses, the angles being worn off by friction.

Its fracture foliated.

Its hardness, 17. Its specific gravity, 3991. It is infusible at 168°, and generally preserves its colour. It is affected by the usual fluxes, as the preceding gems. By the heat of pure air it forms an enamel.

The sapphires, found amidst the ferruginous sand of Expially, near Puys in Velay, seem of this species. Their colour, hardness, and transparency, being similar, and their specific gravity, 4,076. They are very small, their form somewhat irregular from the friction they must have encountered.

According to Mr. Bergman, this stone contains 0,58 argill, 0,35 silex, 0,5 aërated calx, and 0,02 of iron. By Mr. Achard, 0,5833 argill, 0,3333 silex, 0,0666 calx, 0,0333 of iron.

To this family we may also annex the stone called *gyrasole,* of which we have as yet no analysis, and but an imperfect description.

Its colour is white with a slight tinge of red, and a still lighter of blue, which gives it some resemblance to calcedony.

Its lustre, 3.4. Transparency, 3; gives a single refraction.

Its hardness, 15. Its specific gravity, 4,000.

7th Species.—Spinell and Balass Rubies.— The colour of the former a deep, of the latter a pale red, or inclining to orange.

Lustre, 3. Transparency, 3.4. Gives a single refraction.

Its form octohædral, consisting of two pyramids, each of four planes, and joined base to base; or triangular, or trapezoidal plates bevilled on the edges.

Its hardness, 13. The specific gravity of the spinelle, 3,76, of the balass, 3,645.

By Mr. Klaproth the spinelle which he analyzed, and whose specific gravity was only 3,5700, contained, 0,7635 argill, 0,1568 silex, 0,0263 of iron, and 0,0128 calx. The remainder was lost in the operation*. It should be observed, that what is here called silex melted in fixed alkali without effervescence, and therefore it may be doubted whether it be genuine silex.

The stone imported from Ceylon, called *ruby spar,* whose specific gravity is 3,454, is an iridescent of spinell ruby.

8th Species.—1*st Family.*—*Occidental or Brasilian Ruby.*—Red inclining to yellow.

Lustre, 3. Transparency, 3.4. Produces a double refraction.

Shape quadrangular rhomboidal prisms, sometimes with and sometimes without pyramids, often difficult to determine.

Fracture foliated.

Hardness, 16. Its specific gravity, 3,531.

It is infusible *per se,* even by pure air it is barely reduced to a fine-grained porcelain mass.

2nd Family.—*Occidental Topaz.*—1*st Variety, Brasilian.*—Golden yellow, but paler than the oriental and even white.

Lustre, 3.4. Transparency, 3.4. Produces a double refraction.

Shape, as that of the former family, the prisms often longitudinally sulcated.

Fracture, foliated. Hardness, 16. Specific gravity, 3,536.

Exposed to a moderate heat, it is said to become *red*, and then becomes ruby of Brasil; in a stronger, it loses its colour; however, it is fusible at 160°; by borax it may be vitrified, and by the heat of pure air converted into an enamel.

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* 3 Berl. Beob. p. 336.

2d Variety.—Saxon.—Its most usual colour is pale wine yellow, rarely a purer yellow, often yellowish grey, or greyish white.

Its external lustre casual, internal, 3.2. Transparency, 2.3.4. Gives a double refraction.

Its usual form, that of an octangular prism. Four of the angles very obtuse.

The planes longitudinally streaked, and cuneiform pyramids. Often in blunt rounded fragments. Fracture, foliated.

Hardness, 14. Specific gravity, 3,564. The palest called white topaz, 3,553.

When strongly heated it becomes white*, and cracks at 160°. By pure air it is converted into an enamel.

According to Mr. Bergman, it contains, 0,46 argill, 0,39 silex, 0,08 aërated calx, and 0,06 of iron.

By Mr. Weigleb†, 0,5229 silex, 0,4459 argill, 0,025 calx, 0,0031 of iron. This appears the most exact; for a stone, compounded as Mr. Bergman's, should be more fusible; in effect I found a compound, formed exactly as Mr. Bergman's result, to melt at 144° into a greyish black porcelain mass somewhat porous.

3d Variety.—Aigue Marine, by some called

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* Berl. Beob. 15, 16.

† 1 Chy. An. 1786, p. 111.

oriental aigue marine.—Its colour bluish or pale green.

Its lustre, 4. Transparency, 3.2. Double refraction.

Found either in rounded or sharp-edged fragments, or crystallized in hexahædral prisms, as topaz, furrowed lengthways.

Fracture, foliated. Hardness, 12. Specific gravity, from 3,47 to 3,548.

It is infusible *per se.*

3d Family.—Occidental or Brasilian Sapphire.—Its colour of all shades of blue ; often white.

In other respects, it agrees with the preceding.

Its hardness, 15 or 16. Specific gravity, 3,1307.

It is infusible *per se,* but loses its colour in a heat of 130°.

9th Species.—Hyacinth.—Yellowish red, mixed with brown ; one of these colours sometimes predominates, and sometimes the other, but generally the red. Hence we have the dilute red, and sometimes the blood red ; these are often mistaken for garnets ; but these have generally a bluer tinge, and are specifically heavier.

Its lustre, 3. Transparency, 3.4. Double refraction.

Its form may be considered as that of a rectangled quadrangular prism, terminated by two rhomboidal pyramids ; but it generally occurs only in blunted fragments.

Its surface smooth.

Its fracture foliated.

Its hardness, 12 or 13. Specific gravity, from 3,687 to 3,76.

According to Mr. Quist, the reddish yellow hyacinth, which he calls true hyacinth, being packed in sand, acquires a pink colour in a moderate heat; in a stronger it loses its colour, but retains its transparency, and does not melt at 160°; neither can alkalis flux it; but borax and microcosmic salt are more effectual.

The yellowish brown, though it retains its colour in a strong heat, yet melts at 150° or 160° *. Hence these two appear to differ.

Mr. Bergman attributes to the yellower sort, 0,40 of argill, 0,25 of silex, 0,20 aërated calx, and 0,13 of iron; and Mr. Achard, 0,4133 argill, 0,2166 silex, 0,20 calx, and 0,1333 of iron.

I found a compound, formed as Mr. Bergman's result, to form a grey mass not well melted at 144°, yet glazed at the surface; which shews that a few degrees more would effect its fusion, or, perhaps, the same degree, if longer continued.

10*th Species.—Garnet.*—Of this we have three varieties.

1*st Variety.—Oriental Garnet. Carbuncle.* —This is so called, not from its being found only in the eastern countries, but from its greater perfection; viz. hardness, lustre, and transparency.

Its colour, deep or blood red, yet inclining to violet.

Its internal lustre, 3 or 4. Transparency, 4. Double refraction.

Crystallised, and presenting either 12 rhomboidal planes, or 24 trapezoidal, or 36 planes, of which 12 are rhombs, and the 24 others elongated hexagons, interposed between these rhombs; and some other variations.

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* Mem. Stock. 1768.

Fracture, conchoidal.

Hardness, 14 or 13. Specific gravity, from 4,000 to 4,188.

2nd Variety.—Common Garnet.—Deep red, inclining to violet, or verging to black, or olive, or leek green, or brown, seldom yellow.

Its external lustre casual, internal 2.3. Transparency, 2.3.1. Of the brownish and blackish, most frequently, 0. Of the green at most, 2.

Crystallized as the former variety, the surface of the crystals often diagonally seamed, frequently found also in rough rounded grains, or fragments.

Fracture uneven, inclining to the conchoidal, flat or imperfect, often to the splintery.

Hardness, from 10 to 11. Yet sometimes only 9.

Specific gravity, of the red, from 3,941 Werner, to 4,000 Brisson; of the green, from 3,75 to 3,800.

I have found that of some small garnets 3,63.

Both varieties exert most commonly some action on the magnetic needle.

According to Mr. Bergman, they are fusible, *per se,* by the blow-pipe, sometimes into a transparent green glass, but most commonly into a black slagg. Alkalis flux them with great difficulty, borax and microcosmic salt convert them into a green or black glass*. Mr. Gerhard tells us, that in a strong heat they form a grey glass†;

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* 2 Bergm. 105.

† Grundriss. 111.

yet Mr. Fourcroy, in a strong heat of eleven hours, found garnets powdered, barely softened and agglutinated *. Observing these different results, I exposed 35 grains weight of small Bohemian garnets, whose specific gravity, was 3,63, to a blast heat for a few minutes, and found them melted into an opaque dark grey, fine grained porcelain, by a heat of 136°.

By Mr. Bergman's account this stone contains more silex than argill, and more argill than calx; of iron it contains from 0,02 to 0,20.

By Mr. Achard, red Bohemian garnet contains 0,483 silex, 0,30 argill, 0,116 calx, and 0,10 iron.

Mr. Weigleb found the green garnets of Saxony to contain 0,3645 of silex, 0,3083 calx, and 0,2875 of iron †. If so, the green garnets being also specifically lighter, we may suspect them to be specifically different from the red. In another experiment, however, Mr. Weigleb found the argillaceous ingredient also in the green; and so did Mr. Merz; for, in that of Ehrenberg, he found 0,40 of silex, 0,20 argill, 0,08 calx, and 0,20 of iron. The 12 grains missing must have been air and water, and perhaps a casual loss; but it appears the calx is aërated, as Mr. Weigleb found also a considerable *deficit* ‡.

It is commonly found in shistose mica, or gneiss, more rarely in argillites or granites.

3d Variety.—Amorphous Garnet.—Its colour, brownish or blackish red.

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* 6 Buff. Mineralogy 251, in octavo.

† 1 Chy. Ann. 1788, p. 201.

‡ 1 Voight Abhandl. 15, and 22.

Its lustre, 2. Transparency, 2.1.

Fracture, foliated and slaty.

Hardness, 11 or 12. Specific gravity, 3,89. Leske, O. 83.

Found in Sweden, and the East Indies. See Leske, 50 and 83, O; and also in Switzerland by Mr. Saussure.

Mr. Maquart mentions another variety, which he calls the substance of which garnets are formed; it consists of straight fibres, diverging from a common center. Essaies de Minéralogie, p. 373.

11*th Species.—Chrysoberyll**.—Its colour is a dilute yellowish green, but like an opal it reflects, seemingly from its inside a mixed colour of bluish green and yellow.

Its lustre, 3.4. Transparency, 3.4.

Its fracture conchoidal.

Its hardness, 10. Specific gravity, 3,698 to 3,719.

12*th Species.—Chrysolite.*—Its most usual colour is yellowish green, mixed with brown, sometimes verging to the olive green, and sometimes to pale yellow, mixed with grey, seldom allied to reddish brown, or grass green.

Its internal lustre, 3.4. Transparency, 4.3.

It is found partly in sharp uneven indented fragments, often rounded grains, and partly in mutilated crystals, which seem to derive from right-angled quadrangular prisms, whose angles were truncated.

Its surface has a fine splintery or scaly appearance; but such of the crystals as have not been injured by friction have their broadest sides streaked lengthways. Where the surface has not suffered by attrition, it has a considerable lustre.

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* 2 Bergm. Journ. 1790, p. 84, 90. Leske, O. 9. Gmel. Grundr. p. 22.

Its fracture, in every direction, is conchoidal. Fragments, 3.

Its hardness from 9 to 10. Brittle. Specific gravity, from 3,340 to 4,410. Mr. Werner adds, that no stone, whose density is inferior to 3,300, or superior to 3,450, is a chrysolite.

It is infusible at 150°, but loses its transparency and becomes blackish grey. By pure air it is converted into an enamel. Borax and microcosmic salt effect its fusion, but alkalis have scarce any action on it.

The above account is taken, with little alteration, from Mr. Werner's masterly treatise on this stone, in the second part of the Miner's Journal, for 1790. He there shews that this stone hath been frequently mistaken, and that olivins, greenish tourmalines, chrysoberylls, olive green amethysts, prehnites, yellowish green garnets, and dark green crystals, found near Vesuvius, have been taken for it by different writers; nay, that Mr. Romé de Lisle had been so far deceived as to describe crystals of phosphorite, and Saxon topaz, under the appellation of chrysolites. Baron Born, in Raab's Catalogue, fell into similar mistakes.

According to Mr. Achard it contains 0,64 argill, 0,17 calx, 0,15 silex, and 0,0166 of iron*.

13th *Species.—Olivin*†.—Its colour, light brownish green, often inclining to the yellowish and greyish green; and, when withered, to brownish or ochre yellow. Lately also, some have been found of a bluish or mountain green. 1 Berg. Journ. 1792, p. 290.

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* 2 Bergm. Journ. 1790, p. 69.

† 2 Bergm. Journ. 1790, p. 56.

Its internal lustre, 2.3. Transparency, 3.2.

It is found generally in roundish grains, mostly inserted in other stones; but sometimes in large masses, never yet crystallized.

Fracture, conchoidal, approaching to the uneven, seldom imperfectly foliated; and then it is not certain that it is not a different stone; or, perhaps, a variety of the same*.

When large, it presents small-grained distinct concretions easily separable.

Its hardness, 9. Brittle. Specific gravity, from 2,96 to 3,225.

It easily withers by exposure to the open air.

By the experiment of Mr. Voight and Mayer, it is fusible into an enamel in a heat of 150° or 160°.

Hitherto it has been found only in basalts or traps, and not in wacke, or amygdaloids; yet Mr. Lievre assures us, he detected it in some pot-stones on the Pyrenees. 30 Roz. 397.

This stone is attacked by digestion in nitrous acid; and its ferruginous part taken up; but chrysolites are not affected by this acid; and thus we have a sufficient criterion whereby to distinguish them.

14th *Species.*—*Obsidian.*—Icelandic agate of some, lux sapphire of Hungary.

Its colour, black or greyish black; in very thin pieces dark green.

Its internal lustre, 3. Transparency, 1.

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* 1 Bergm. Journ. 1792, p. 242.

It is found in detached masses, or inherent in gniess, granite, or porphyry; generally invested with a grey opaque crust. Fichtel says it has been found in the form of a twelve-sided pyramid*.

Its fracture, perfectly conchoidal, sometimes iridescent.

Hardness, 10. Specific gravity, 2,348.

It melts into a grey opaque mass.

According to Mr. Bergman, Icelandic agate contains 0,69 silex, 0,22 argill, 0,09 iron.

We have no reason to suspect it of volcanic origin, as it is found in Hungary, inhering in gniess, and disintegrated granite. Gerh. Miner. Syst. 283.

15th Species.—Shorl. Schwartzer Stangen Shorl of Werner.—Its colour is black.

Its lustre 2, common. Transparency, 0.

It is found either in masses of indeterminate form, or crystallized in three or nine-sided prisms, which, when entire, are terminated with three-sided summits.

The surface of the crystals is longitudinally streaked.

The amorphous sort presents thin, straight, distinct, columnar concretions; sometimes parallel, sometimes diverging or stelliform, streaked, and easily separable from each other; very seldom irregular granular concretions.

Its fracture conchoidal, verging to the uneven; and hence often resembling the striated.

The longitudinal fracture, foliated.

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* Beytr. Zur. Mineral Gesch. Siebenburgh, Theile. 1, p. 143.

Its fragments, 3. Gives a grey streak.

Its hardness, 10. Its specific gravity, from 2,92 to 3,212.

When heated to redness, it alters its colour in cooling, to a brownish red; at 46°, it becomes redder; at 65°, it does not melt; but at 127°, it is converted into a brownish black compact enamel; at 147°, it becomes more porous, and its surface somewhat redder. I found its specific gravity after exposure to that heat 2,143, from the number of small pores.

The word shorl so frequently occurs in mineralogical writings, and has been so often applied to stones of various species, not only by different, but often even by the same author, that it becomes necessary to point out the different senses in which it occurs amongst the most eminent of those writers.

The term itself is derived from the Swedish *skorl*, brittle, and was first used by Cronstedt to denote a class of stones of a columnar form and considerable hardness and density; their specific gravity being from 3 to 3,4. But it unfortunately happened, this class of stones comprehended many of different species, such as basalts, actinolites, &c. And, as he translated this word into Latin by the basaltes, the confusion was thereby increased.

He does not, however, pretend it is always crystallized; for, he distinguishes four sorts, the last of which only is, he says, crystallized.

1st, *The amorphous martial shorl, or skorl-birg;* this, Wallerius tells us, is his own 148th species, of a green or yellowish green colour; its specific gravity 3,200, difficultly, if at all, giving fire with steel. This is now what is called the gemeiner, or common actinolite of Werner, as far as this takes in the amorphous sort only.

2nd, *The shorl spar* of a green and sometimes of a white colour; this is the *basaltes spathosus* of Wallerius, and probably denotes the green foliated hornblende and shorlite.

3d, *The fibrous, or strahl shorl*, black, green, and white; the *basaltes fibrosus* of Wallerius, which is the crystallized common actinolite of Werner.

4th, *The shorl crystal*, which he translates *basaltes crystalisatus*, of which he distinguishes three colours, the black, green, and reddish brown; as does Wallerius, who, deceived by the name, comprehends also the pillars of the Giant's Causeway under this species. The black, however, is the real shorl; the other colours probably comprehend actinolites and tourmalines.

Mr. Bergman also distinguishes three sorts of shorl, the *fibrous*, which he mentions in his treatise on asbestos, the crystallized, and the scaly; this last he also calls hornblende*; but the first melts, *per se*, into a grey porcelain mass, and therefore does not belong to this species; the crystallized is softened indeed by the blow-pipe, but is scarcely melted into a bead, whereas hornblende melts easily, and therefore they are not of the same species; he also owns, that the crystallized sort emulates the hardness of crystal, whereas hornblende may be scraped by a knife. Again he distinguishes the crystallized into transparent and opaque; the transparent are yellow, or brown, but mostly green; the opaque, also, black or green.

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* 2 Bergm. 107.

Thus the tourmalines also, to say nothing of basaltic hornblendes, will be comprehended under this denomination.

Mr. Saussure's definition of the characters of this stone is also too comprehensive; it is, he tells us, "a hard bright crystallized stone, partially soluble without effervescence in acids, and fusible *per se*. Its hardness, 10; its fracture, vitreous; its specific gravity, far exceeding that of crystal; its colours, green, yellow, or black;" to which he afterwards adds white, and also basaltic hornblende.

Mr. Romé de Lisle constantly confounds shorls, actinolites, tourmalines, and basaltic hornblendes; yet he owns that he long hesitated whether he should not consider these last as a distinct species; he calls them volcanic shorls.

To Mr. Werner's sagacity we owe the precise characters by which these different species are now accurately discriminated; and which we have enumerated in treating of each.

From the indiscriminate application of this name to stones of different species, we are at a loss to know to which of them the few analyses we have of shorls should be particularly applied.

Mr. Bergman, in his Treatise on Gems, tells us, that shorl contains a greater proportion of silex than garnet does (and in garnet the siliceous is the most copious ingredient); next to that the argillaceous; and next to that the calcareous is the most prevalent. In black shorls, he tells us, iron is in the proportion of 20 per cent. however as he mentions yellow, brown, and green shorls, it is uncertain to which of them this gradation of ingredients should be attributed.

Mr. Weigleb, indeed, seems to have analyzed the genuine shorl of which we here treat; yet his account differs in many circumstances from that of all other chemists; for, in the first place, he found that unless the union of its constituent parts were weakened by calcination with an alkali, spirit of nitre, even by long digestion, could dissolve no part of it[*]. And again he tells us, it contains no calx, but only 0,3416 silex, 0,4125 argill, 0,20 iron, 0,0541 manganese[†].

Mr. Chaptal, on the other hand, relates, that he found in the black prismatic shorl of Gevaudan, 0,52 silex, 0,37 argill, 0,05 calx, 0,03 manganese, and 0,03 of iron. 2 Chaptal, p. 123.

Mr. Saussure also informs us, that the shorls he examined were in great measure soluble in nitrous and all the mineral acids without any previous operation, and contained both magnesia and calx, as well as argill, silex, and iron. 1 Sauss. p. 64, 65, &c.

Mr. Bergman even thinks calx an ingredient essential to shorl[‡]. In the analysis he gives us of the black crystallized shorl of Mount Albano, he found both calx and magnesia, but this was most probably a basaltic hornblende.

Mr. Bindheim also found 21,6 per cent. of calx in what he calls prismatic shorl discovered in limestone in the Carpathian Mountains; but it is not clear, as no description is given, what stone it really was. Mr. Bergman thinks it was a zeolyte[§].

I tried Mr. Weigleb's result synthetically, and found a compound exactly formed as his result, omitting only the manganese, scarcely fusible at 148°; it formed only a greenish black porous slagg.

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[*] 1 Chym. An. 1785, p. 246.

[†] 1 Crell Beytrage, 4 Stuck, p. 33.

[‡] Schwed. Abhand. 1784, p. 113.

[§] 2 Chy. Ann. 1784, p. 396.

To comprehend in one view the different significations of this term, we may observe, that what are called,

White shorls, are shorlites, or acicular baroselenites;

Yellow, basaltic hornblendes;

Reddish brown, basaltic hornblendes, and sometimes tourmalines;

Green, if fibrous, shorlaceous, or vitreous actinolites; if grosser, prehnites; sometimes even hornblende is called green shorl*.

Violet, thumerstein;

Blue, sappare;

Black, and *hexagonal*, or *volcanic*, are also basaltic hornblende;

Red shorls, longitudinally streaked, have been lately found in Hungary. 1 Raab. 168. I have also observed one in Leske's collection, O. 171; but so small, and so firmly stuck in quartz, that I could make no experiments upon it. Rubellites are also so called.

16*th Species.*—*Tourmaline.*—The usual colour is brown, often so dark that, when not held to the light, it seems black, yet often so light as to approach to the hyacinth red; sometimes it verges to the olive green, or dark green; it is even found blue. Mr. Bergman tells us, that of Ceylon is dark brown, or yellowish; that of Brasil, greenish, bluish, reddish, or yellowish brown; that of Tyrol, by reflected light, blackish brown; but, by transmitted light, yellowish; or, in thin pieces, greenish. That of Switzerland blackish.

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* For instance, by Mr. Besson, see Estner Freymuth Gedanken, p. 37, 38.

Its internal lustre, 2.3. Transparency, 3.4.2. and 1, when black.

It is found in detached blunt-edged pieces, or grains, or crystallized in slender three or nine sided prisms, with a tetrahædral summit.

The surface of these crystals is often smooth, but often also longitudinally seamed.

Its fracture conchoidal, yet sometimes discovers some tendency to the foliated.

Fragments, 3. The detached amorphous pieces discover columnar concretions.

Its hardness, from 9 to 11. Specific gravity, from 3,05 to 3,155.

But its most remarkable character is the electrical power it acquires when heated to about 200° of Fahr. so that it attracts and repels ashes, and other light bodies; yet this property is said to have also been found in opaque shorls. 2 Bergm. p. 124.

It reddens when heated, and is fusible *per se*, the crystallized with intumescence; and that from Ceylon or Tyrol forms a *whitish* spongy enamel; the uncrystallized, that of Brasil, melts more difficultly.

Hence we see that tourmalines differ from shorls generally in colour and transparency; but chiefly in the results of their fusion.

Neither microcosmic salt, nor mineral alkali, readily flux it; nor borax, though its action is more sensible.

The mineral acids extract both calx and iron from it when barely pulverized, and after long digestion or distillation; but do not decompose it perfectly without particular management.

The proportion of ingredients in the tourmalines of Ceylon, Tyrol, and Brasil, according to Mr. Bergman, and in that of Mount Gothard, in Switzerland, according to Struvius, is as follows:

	Ceylon.	*Tyrol.*	*Brasil.*	*St. Gothard.*
Silex	37	40	34	37,5
Argill	39	42	39	38,5
Calx	15	12	11	10
Iron	9	6	5	9

*17th Species.—Thumerstone**. *Shorl Violet de Dauphiné, Glass Shorl of some.*—Its colour is clove brown, often very light, or inclining to red, greenish, or pearl grey; or inclining to violet, or black.

Its lustre, 2. Transparency of the amorphous, 2.1; of the crystallized, 3.4.

It is found either amorphous or crystallized; the amorphous is lamellar, and nearly foliated.

The crystallized forms flat rhomboidal crystals, whose angles are truncated.

The faces, except where truncated, generally longitudinally streaked; the grey are often cellular, and the cells filled with the brown variety.

The fracture, minute conchoidal, inclining to the uneven. Fragments, 3.

Its hardness, 10.9. Brittle. Specific gravity, 3,2956.

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* 1 Bergman, Journ. 1788, p. 55, and 262. 1 Helvet. Magaz. 180.

When heated little above redness, it swells and foams like zeolite, which proves it to be specifically different from shorls, and at last melts into a hard black enamel.

According to Mr. Klaproth, it contains 0,527 silex, 0,256 argill, 0,094 calx, 0,096 calx of iron, and some manganese.

It is found crystallized in Dauphiné, and near Bareges, and amorphous in Saxony, near Thum, whence Mr. Werner calls it Thumerstein.

18*th Species.—Prehnite* *.—This stone has been denoted by various names.—By some it has been called green shorl; by others, emerald, or prasium, or chrysoprasium; and even feltspar, and chrysolite, and zeolite of the Cape.

Its colour is apple green, or greenish grey, of various degrees of intensity.

Its external lustre, 2. Its internal less, and of the pearly kind. Its transparency, 3.2.

It is found both amorphous and crystallized. The amorphous presents either a foliated or striated texture; the foliated consists of large or small-grained distinct concretions, and the striated forms imperfect, slender, columnar concretions. The crystallized forms either low, small, compressed, flat, quadrangular prisms, or tables; and some with truncated angles, and heaped together or in groups.

The principal fracture is foliated, seldom striated; the cross fracture uneven, and fine grained. Its hardness from 9 to 10. Brittle. Its specific gravity, 2,9423.

Exposed to the blow-pipe, it swells and foams when heated to redness still more than zeolites

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* 1 Bergman's Journal, 1790, p. 110. 32 Roz. Journ. 82. 1 Ann. Chy. 202.

do, and melts into a brown enamel, smooth on the outside, but spongy and porous underneath.

Of the usual fluxes borax is the most effective; with alkalis it forms only an enamel, but microcosmic salt forces it into an opalescent glass.

By the analysis of Mr. Klaproth, it contains 0,4383 silex, 0,3033 argill, 0,1833 calx, 0,0566 iron, and 0,0183 of water end air.

By that of Mr. Hassenfratz, 0,50 silex, 0,204 argill, 0,233 calx, 0,049 iron, 0,009 water, and 0,005 magnesia.

This stone was first found near the Cape of Good Hope by Capt. Prehn, hence Mr. Werner calls it prehnite. Lately, it has been discovered near Dumbarton, in Scotland, by that accurate observer Mr. Grotsche. It has also been found in Dauphiné.

In lustre, texture, and intumescence, it resembles zeolites, but differs in hardness, specific gravity, colour, relation to fluxes, and also in constitution, for it contains iron; neither does it gelatinate with acids, as zeolites do. On the other hand, it differs from shorls, by its fracture, intumescence when heated, greater fusibility, and the porosity of its enamel. Hence Mr. Werner justly considers it as a particular species, but nearly allied to zeolite.

19th *Species.—Ædelite, or Siliceous Zeolite**.—Its colour is light grey, sometimes with a tinge of red, or yellowish brown, green, or yellowish green.

Its lustre, 0.1.

Its form, tuberose, or knotty.

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* Schwed. Abhandl. 1784, p. 114.

Its fracture, striated, but sometimes splintery, like quartz.

Its hardness from 9 to 10. Specific gravity, 2,515, when penetrated with water, of which these stones absorb about $\frac{1}{18}$ of their weight, and sometimes more.

The external characters are but imperfectly given, as I neither possess any specimen, nor have seen any just description of it.

Treated by the blow-pipe it intumesces, and gives a frothy mass.

It contains from 0,62 to 0,69 silex, 0,18 or 0,20 argill, 0,08 or 0,16 calx, and 0,03 or 0,04 of water. Per Bergman, Mem. Stock. 1784, p. 114.

These stones have hitherto been only found in Sweden, at Adelfors, and Messeberg, and must not be confounded with zeolites mixed with silex or calcedony, which are much more common, and abound in Auvergne. They have hitherto been classed with common zeolites, because they consist of silex, argill, and calx, in a proportion progressively diminishing, and answer to Mr. Bergman's formula *sac*, as he himself tells us, and because they contain water, and swell or froth before fusion, and have a striated texture. But, if these reasons were valid, prehnite should also be reckoned a zeolite; for, its composition corresponds with the formula *sac*; it contains water, intumesces before fusion, and has a striated texture; yet most mineralogists consider it as a distinct species; the proportion of ingredients must be considered, and in this case the *proportion of* water, which I look upon to be essential to zeolites, is wanting; for this stone contains only 3 or 4 per cent. a proportion not exceeding

ing that in several other species of stones, and merely accidental; indeed, any quantity below 5 per cent. (except a metal) makes no alteration in the notable properties of any stone, as I have before remarked.

On the other hand, a hardness, not sufficient to give fire with steel, is a property laid down as one of the criteria of zeolites by Cronstedt, otherwise sufficiently careless of external characters; and, in effect, is found in all those that possess the true constituent parts of zeolite, and in due proportion; besides, its specific gravity is considerably greater than that of zeolites. The absence of iron is not a sufficient reason to annex it to zeolites; for even Bergman allows that zeolites may contain 1 per cent. of iron.

Hyalites approach much nearer, and yet are a distinct species.

The red zeolite of Adelfors is generally reckoned among the zeolites that strike fire with steel[*]; yet Mr. Bergman expressly tells us it gives no sparks. Schwed. Abhandl. 1784, p. 115. And Swab. 2 Mem. Swed. p. 434.

20th Species.—Zeolite[†].—Its colour is white, yellowish, or reddish white, brick red, greenish, or blue.

It is found both amorphous and crystallized, the latter in cubes, or hexahædral parallelopepids, or tables, or cuneiform, or capillary, or in triangular pyramids[‡]; sometimes with 24 or 26 faces, &c.[§]: the former frequently in a mealy or sandy form.

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[*] Briss. p. 142. 2 Berl. Beob. 221.

[†] Born. Phys. Arbeitung 2 Stuck. p. 72.

[‡] Chy. Ann. 1790, p. 432.

[§] Dolom. on 3 Bergm. 245.

Its lustre, silky or pearly, 2.3.1. Transparency, 2.3.4.1.

Its texture, fibrous or striated, often both in the same specimen; either stelliform, or scopiform; rarely foliated, and only when crystallized in hexahædral prisms. Fragments, 2.

Its hardness, from 6 to 8; rarely 4. It absorbs from $\frac{1}{30}$ to $\frac{1}{174}$ of its weight of water.

Its specific gravity before absorption, is from 2,07 to 2,214; and, after absorption, from 2,13 to 2,3; but sometimes it is mixed with quartz or calcedony, and then may rise to 2,4.

It is partially and slowly soluble in the three mineral acids without effervescence, and if they be not in too great quantity, it *gelatinates* most commonly. The acetous acid, at least the common, does not affect the gelatination. The siliceous part, being undissolved, is that which forms a jelly. Radical vinegar dissolves the calcareous part. Sometimes an instantaneous effervescence may be produced, as in the red foliated zeolite of Adelfors. 2 Mem. Swed. p. 436. But this arises from a slight quantity of calcareous spar, with which it is contaminated. Van Troil, p. 375. Mem. Swed. 454.

When heated, most zeolites froth and foam nearly as alum, before fusion emit a blue phosphoric light, and finally melt into a white semitransparent frothy enamel, not hard enough to cut glass, and which is itself soluble in acids*. Mineral alkali promotes their vitrescence most, next borax, microcosmic salt least. 3 Bergm. 226.

The zeolites analyzed by Mr. Bergman, Mayer, and Pelletier, contained as follows:

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* 2 Born, Physic; Arbeit. p. 73.

Silex.

	Silex.	Argill.	Calx.	Water.	
Bergman	0,48	0,22	0,14	0,16	Zeolite of Iceland.
Ditto	0,80	0,095	0,065	0,04	Red of Adelfors Van Troil, p. 368, 370, and 374.
Mayer	0,583	0,172	0,06	0,175	A striated. 4 Berl. Beschaft. 330.
Ditto	0,41	0,31	0,11	0,15	A do. 2 Berl. Beschaft, 475.
Pelletier	0,50	0,20	0,08	0,22	Of Feroe.
Rinman	0,55	0,025	0,262	0,17	Zeolite of Hællestadt. Swed. Abhand. 1784, 66.
Bergman	0,55	0,025	0,247	0,17	And fixed air; 0,003 iron, and 0,005 magnesia, in the same stone. Ibid. 115.

Hence we see that any proportion of silex, argill, calx, and water, is sufficient to constitute a zeolite, so that the silex exceeds, and that the compound is fusible to an enamel. For, the zeolite of Hællestadt possesses the properties of a zeolite, though the proportion of argill be smaller than that of calx, contrary to what happens in all the other zeolites.

Hence Mr. Bergman's formula should here be *sca,* and not *scam,* as the proportion of magnesia is absolutely insignificant, and iron is ever accidental in this species. Pure zeolite necessarily excludes it. I must also add, that the specific gravity of zeolite of Hællestadt exceeds that of other zeolites, being 2,417.

Zeolites generally possess two properties, viz. gelatination with the mineral acids, and intumescence before fusion; neither of which is peculiar to them, but one or other of them seems essential to them; and both, I believe, are possessed by no other substance, except lapis lazuli, which intumesces only in a very high heat, and gelatinates only after calcination.

1st, As to gelatination. Mr. Swab observed, that a mixture of equal parts, fine clay and lime, forms a glass which gelatinates with acids. So does a melted mass of equal parts, lime and quartz. 2 Mem. Swed. p. 443. The clay in the former experiment also contains silex. Mr. Pelletier found the siliceous ore of zinc, also to gelatinate, but does not intumesce.

On the other hand, all zeolites do not gelatinate, per Mr. Swab, 2 Mem. Swed. 455. 3 Bergm. p. 228. The zeolites of Hallestadt also gelatinate, but not, until previously calcined, per Mr. Swab, Swed. Abhandl. 1784, p. 60. The zeolites of the Hartz do not gelatinate; neither do the crystallized of Iceland, or Feroe, as some say*.

Again, as to *intumescence*, several stones intumesce before fusion, as prehnite, thumerstein, lilalite, &c. and several zeolites, do not intumesce, per Bergman, Swed. Abhandl. 1734, p. 115, or only very slightly.

As zeolites imbibe water, they frequently effloresce by exposure to the air; and as they exist in a rounded form in traps, the cavities in these frequently arise from the falling or washing out of the mouldered zeolites.

This stone often passes into calcedony,

21*st Species.—Staurolite, or Cross Stone of St. Andreasberg, in the Hartz*†. *Kreutz Crystal of the Germans. Hyacinth blanche of* 2 *Romé* p. 299.—Of this stone there are two varieties.

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* Lasius Hartz, p. 335. 2 Lempe Maga. p. 59.
† 2 Bergbau. p. 23.

rieties. The second is very scarce, having occurred but once.

The colour of the first is milk white; of the second, brownish grey.

Their shape is that of two quadrangular tables, or flat quadrangular prisms, bevilled at the edges, and intersecting each other at right angles. Some difference may take place as to the form of the edges, and the angle of intersection.

The crystals of the second variety are most commonly sulcated.

The lustre, both external and internal, is variable. Of the first generally 2; and of the waxy kind, that of the second pearly; and somewhat stronger than that of the first.

Transparency, 1.2.3. The fracture of both is foliated. Fragments, 3.

Hardness, 9. Brittle. Specific gravity of the first, 2,355; of the second, 2,361.

Gradually heated, both decrepitate and lose 0,15 or 0,16 of their weight, and as some say, slightly intumesce*, and then fall in powder. This powder is infusible at 150°, but by pure air is converted into a white enamel.

Mineral alkali fluxes both varieties into a frothy enamel; that of the first is white, that of the second purplish and yellowish. Borax and microcosmic salt effervesce, but scarcely unite to them, yet reduce them to a porous greenish opaque mass.

Acids do not sensibly effervesce with them, yet they have some action on them; as the concentrated vitriolic takes up a little argill, and the nitrous and marine, also argill and barytes;

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* 2 Lempe Mag. p. 59.

but, after calcination, aqua regia, slightly effervesces with them, and takes up some argill and barytes.

According to Mr. Westrumb, the first variety contains 0,44 silex, 0,20 barytes, 0,20 argill, 8,16 of water. The second variety contains 0,475 silex, 0,20 barytes, 0,12 argill, 0,16 water, and 0,045 iron and manganese.

According to Mr. Heyer, the first variety contains 0,44 silex, 0,24 barytes, 0,20 argill, and 0,12 of water.

This stone is commonly considered as a zeolite; but we see that its composition is totally different.

22nd Species.—*Lapis Lazuli.*—Its colour is of different shades of blue, mostly light, or deep azure, with white spots of quartz, and often with bright yellow specks, or veins of sulphur pyrites.

In shape amorphous.

Its lustre, 0. Transparency, 0.1.

Fracture uneven, nearly earthy. Fragments, 2.

Hardness, from 8 to 9. Specific gravity, from 2,76 to 2,945 Brisson.

A specimen of my own collection, very pure, 2,896.

It retains its colour in a heat of 100°, which distinguishes it from cupreous stones, but in a higher heat it intumesces, and melts into a yellowish black mass, and in a still higher, to a whitish enamel. 2 Margra. p. 323, 324.

If pulverized and treated with acids, it gives some signs of effervescence; if calcined it does not effervesce, but gelatinates with the mineral acids. Magr. Ibid. p. 319.

It has not as yet been properly analyzed. Margraaf's enquiries were chiefly directed to the investigation of copper. He found none, but barely iron, silex, calx, and gypsum. Mr. Rinman detected the sparry acid, § 201.

It is found only in the confines of Siberia and Tartary, or China; and lately, as is reported, in America.

23d Species.—Chrysoprasium[*].—Generally of an apple, or light leek green, sometimes approaching to the grass green, or to the olive green, or pale greenish grey.

Always amorphous.

Lustre, 1, almost 0. Transparency, 2.3.

Fracture, even, or inclining to the splintery. Fragments, from 2 to 3.

Hardness, from 10 to 12 Specific gravity, 2,479, by my trial.

Heated to 130°, it loses its colour, whitens, and becomes opaque. It is infusible at 168°; by pure air it gives a white compact enamel. Powdered and heated with two parts vegetable alkali it gives a violet glass; with mineral alkali or borax, it gives a brown glass; with microcosmic salt, a honey yellow [*].

By the analysis of Mr. Klaproth, in which the most consummate skill and accuracy are displayed, it contains 0,96 of silex, 0,01 calx of nickel, 0,0083 lime, 0,0083 argill. and 0,0083 calx of iron.

It often passes into calcedony.

24th Species.—Vesuvian, or White Garnet of Vesuvius.—Its colour, white or greyish white.

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[*] Werner's Cronst. p. 99.

[†] 2 Berl. Beob. 2 Stuck. p. 39, and 40.

Always crystallized, either with 12, 18, 24, 36, or even 56 faces, sometimes pentagonal, trapezoidal, or triangular, &c. from the size of a pin's head to that of an inch; and frequently decomposed. Found principally in the lava of Vesuvius, or other ancient lavas, particularly in Italy, and in the primordial stones of Vesuvius.

Gioeni 37. But lately also in some granites of the Pyrenees, and among the gold ores of Peru. 40 Roz. Journ. p. 393.

Lustre, 3; but, as they are commonly in a state of decomposition, 0.

Transparency, when fresh, 3.2; but generally from decomposition, 0.

Fracture, foliated, inclining to conchoidal.

Hardness when intire, from 8 to 9; when mouldering, 5 or 6. Specific gravity, 2,4648.

Fusible *per se* by the blow-pipe, but difficultly. Mineral alkali scarcely fluxes them, borax and microcosmic salt, very slowly.

Mr. Bergman found them to contain 0,55 silex, 0,39 argill, and 0,06 lime, but no iron, or scarce any. 3 Bergm. p. 206.

The decomposed state of this stone does not proceed merely from the action of the air, nor exposure to sulphureous vapours, but principally from the heat to which it was exposed; for it is found opaque, and mouldering even in the midst of solid masses of lava, as Mr. Werner has observed. 4 Helvet. Magaz. p. 241.

25th Species.—Shorlite. Shorlartiger Beryll of Werner's Mineral System. Stangenstein of Leske.*—Its colour, greenish white, sometimes inclining to yellowish, or sulphur yellow.

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* Werner's Cronst. p. 169. Weissen stangen shorl. 1 Chy. Ann. 1788, p. 390.

Mostly found in irregular oblong masses or columns, inserted in a mixture of quartz and mica, or granite. Mr. La Peyrouse tells us, he found some in small lamellar masses on the Pyrenees*.

Lustre, 2. Transparency, 2.1.

Its fracture, uneven, and, seemingly, somewhat foliated.

Hardness, from 9 to 10. Specific gravity, 3,530, per Klaproth. 1 Chy. Ann. 1788, p. 390.

Infusible at 168°, and no way altered by heat.

Mr. Ferber mentions a white shorl found in the Bannat, which phosphoresces when scraped in the dark. Nov. Acta. Petrop. 1785, p. 264.

By the analysis of Mr. Klaproth it contains 0,50 silex, and 0,50 argill; by that of Mr. Bergman, 0,52 argill, 0,46 silex, and 0,02 water.

This substance was called *shorlite* by Mr. Klaproth, than whom we cannot have a better guide. It cannot be the substance called *white shorl* by the French; as Abbé Hauy thinks this rather of the feltspar species; and Mr. D'Arcet found it fusible in a porcelain heat, and so did Mr. Chaptal; and accordingly it contains 0,55 silex, 0,25 argill, 0,13 magnesia, and 0,07 lime. By his analysis, 2 Chaptal, p. 124. But that called white shorl by Mr. La Peyrouse is most probably our shorlite; for, he found it infusible in the strongest heat.

The *white shorl* of the French, at least of

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* 26 Roz. 434.

Mr. Chaptal and Abbé Hauy, is most probably that sent to Saxony by Mr. Shreiber from Dauphiné, of which Mr. Hoffman gives the following description* :

Its colour is greyish white, but being covered with iron ochre, it seems of a smutty yellow. Crystallized in quadrangular thin tables, whose edges are somewhat convex, and heaped on each other.

Its external lustre, 2. Internal, 1. Transparency, 3.

Its fracture compact, approaching to the even. Its fragments, 3.

Its hardness, 10. Its specific gravity he could not determine.

Shorlite passes into feltspar.

26th Species.—Rubellite, *Red Shorl of Siberia*†.—Its colour, crimson, blood, or peach red.

It occurs in accumulated groups, of a middle or large size, with straight tubular-like striæ. Its surface rough.

Its external lustre, 2. Internal, 2,5 Transparency, 2, at the edges 3 ; transmitting a yellowish colour.

Its longitudinal fracture delicately fibrous, with slender distinct concretions.

Its cross fracture even, inclining to the conchoidal.

Fragments, 3. Hardness, 10. Brittle. Specific gravity, 3,100.

Heated to redness, it becomes snow-white, and seems to phosphoresce, but loses no part of its weight. In a higher heat it is infusible. Mineral alkali is tinged blue by it, but scarcely fluxes it; neither does borax, nor microcosmic salt, effect its fusion.

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* 1 Bergm. Journ. 1788, p. 57.

† 2 Chy. Ann. 1792, p. 320.

By the analysis of Mr. Bindheim it contains 57 per cent. of silex, 35 argill, 5 calx of iron and manganese.

27th Species.—Of this I distinguish four families; opal, semi opal, pitch-stone, or pechstein, and ligniform.

1st Family.—Opal Edler, and Gether Opal of Werner.—Its colour is generally of a light bluish white, sometimes yellow or green. The white often emit a yellowish, greenish, or reddish effulgence, resembling a flame, when the eye is placed between it and the light; as do the yellow, a fiery; and the green, a purple, red, or yellow. Those that possess this varying splendor are called *oriental opals*, though they are not found in the east; and those that present but one colour are called common, or vulgar opals*.

Amorphous, interspersed, or in sharp fragments.

Its lustre, 3. Glassy. Transparency, 3.2.

Its fracture perfectly conchoidal. Fragments, 3.

Its hardness, from 6 to 8. It is said to have sometimes occurred in a soft state, and to have hardened by exposure to the air. Its specific gravity, from 1,700 to 2,144.

It frequently contains a drop of water. A specimen of this sort occurs in Leske's Collection, O. 841.

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* 2 Bergm. Journ. 1788, p. 487.

It is infusible *per se* at 150°; it yields most readily to mineral alkali, next to borax, but scarce at all to microcosmic salt.

By Mr. Bergman's analysis it contains 0,85 silex, 0,13 argill, contaminated with iron. By that of Klaproth, the white opal of Kosemitz contains 98,75 silex, 0,01 argill, and 0,01 of iron. The green derives its colour from calx of nickel*.

It is often found decomposed by exposure to the atmosphere.

I found the opal 844. Leske, O. Infusible at 151°; and so are all opals found to be.

2nd Family.—Semi Opal†.—Its colours are, bluish, pearl, reddish, greenish, or yellowish grey; greyish, reddish, or yellowish white, or honey, or wax yellow; or flesh, or hyacinth red; or reddish brown, or yellowish, or liver brown; or grass, leek, or verdegris green, or many of these in the same mass.

Amorphous or in sharp fragments.

Its lustre, 2. Glassy. Transparency, 2.1.3.

Its fracture conchoidal, sometimes imperfectly. Fragments, 3.2.

Hardness, from 7 to 9. Brittle. Specific gravity, 1,7 to 2,118.

Some adhere to the tongue by reason of the rifts they contain; these admit water, and are often hydrophanous, as we shall presently see.

It is infusible as the former family.

It differs from opals always in lustre, and often in transparency, fracture and hardness.

Its transitions are into horn-stone, calcedony, chrysoprasium, jasper, and quartz; and, when decomposing, into porcelain clay.

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* 2 Berl. Beob. p. 45.

† Werner's Cronst. p. 123.

The semi-opal of Leske, S. 658, much resembles flint, but does not give fire with steel.

There is a variety of the semi-opal called a *Pyrophanes;* because, being heated on a spoon, it becomes transparent, but returns to its opaque state when cold, as Mr. Landriani has discovered*. Mr. Saussure, jun. renders common hydrophanes transparent, and of a topaz colour when heated, by digesting them in melted wax.

It is said that some pyrophanes are found in Armenia, which are transparent while exposed to the sun, and opaque at night†.

3d Family.—Pitch-stone‡.—Its colours, greyish black; bluish grey; mountain leek or olive green; greenish brown; brick or blood red, or yellowish colour; sometimes many in the same mass. Found in large masses; and, lately, also crystallized in six-sided prisms, with triangular pyramids. Lustre, of the greasy kind, 3.2.1. Transparency, 2.1., rarely 0.

Fracture, imperfectly conchoidal, and uneven, often approaching to the splintery, the longitudinal fracture sometimes slaty. Fragments, 2.3.

Hardness, from 8 to 10; and exceeding brittle. Specific gravity, from 2,049 to 2,39. It is true, Mr. Brisson found that of a brick red from Saxony, 2,6695, but it was probably impure. I found another of them, Leske, 251, G. to be 2,720.

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* 1 Chy. Ann. 1791, p. 483.

† Chy. Ann. 1792, p. 35.

‡ Werner's Cronst. p. 124.

It frequently presents either large or small grained distinct concretions.

It often much resembles semi-opals and jaspers, but differs from the former always in the *kind* of lustre, and often in fracture; from the latter always in brittleness, and mostly in transparency. The brick red of Saxony, whose specific gravity was 2,720, had scarce any lustre or transparency, and rather seems a jasper, or between a hornstone and jasper, and pitchstone, for it had several separate concretions divided by white seams.

As to fusibility, there seems a great difference in different specimens.

1st, The pitchstone, Leske, O. 870. Of a leek, partly inclining to an olive green, whose specific gravity is 2,298, and melted at 165° into a white frothy enamel.

2nd, Another of the same collection, O. 873, which had scarce any lustre, and no transparency, or, scarcely 1, and whose specific gravity was 2,267; its colour between a mountain and an olvive green, and exhibiting curved lamellar concretions, melted at 130° into a fine small-pored white enamel. This seems allied to felspar.

3d, Another of Leske, G. 251, brick red from Misnia, in Saxony, which had but little lustre, and scarce any transparency, whose specific gravity was 2,720. Its fracture uneven and splintery, did not melt at 160°, but remained a loose brownish red powder. Is it not rather an iron shot quartz?

4th, Another of Leske, S. 295, pearl grey, much resembling porcelain jasper, its lustre being silky, whose specific gravity was 1,970, decrepitated strongly when heated, then whitened, but at 149° it remained a loose powder.

5th, Another of Leske, S. 949, yellowish brown, and semi-transparent. Its specific gravity, 2,266, at 152° melted into a white small-pored porcelain mass.

The different degrees of fusibility arise from the different proportion of its ingredients, or its mixture with extraneous substances.

Mr. Weigleb found in that of Saxony, of a dull brown colour (probably 873 O. of Leske), 0,73 silex, 0,18 argill, 0,058 iron, the remainder water and air. 11 Neu. Entd. p. 18. Mr. Mayer of Stettin, found the same ingredients, and nearly in the same proportion, in the greyish black, besides water, and some traces of sal-ammoniac. 2 Crell. An. 1784, p. 125.

Mr. Gmelin, in a kind of pitchstone stuck in basalt, found 0,90 silex, 0,07 argill, and 0,026 of iron. 1 Chy. Ann. 1791, p. 301.

Mr. Klaproth, in that of Mesnilmontant, which was of a reddish yellow colour, and whose specific gravity was 2,1685, found 0,855 of silex, 0,1 argill, and 0,005 of iron, of calx and magnesia 0,005, water inflammable matter and air 0,11.

The greyish black of Hungary were found infusible by Mr. Ruprecht: they decrepitated and whitened like that of Leske, 295 S. abovementioned, and afforded him 0,91 silex, 0,08 argill, and some traces only of iron and inflammable matter also, for they slightly deflagrated with nitre, and render the vitriolic acid somewhat brown*.

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* Phys. Arbeits. 2 Stuck. p. 55.

In another pitchstone, found near Frankfort on the Maine, whose colour was nut brown; and which was in some degree magnetic, and infusible in a porcelain heat, Mr. Weigleb found 0,8958 silex, 0,05 iron, 0,0333 calx, and 0,0041 argill. 1 Chy. Ann. 1788, 398.

From all these analyses it is plain, that opals and pitch-stones consist essentially of silex, with about from $\frac{1}{6}$ to $\frac{1}{100}$ of argill, and some water and inflammable matter. If to these, when the argill is about $\frac{1}{12}$ of the whole, 5 or 6 per cent. of iron, be added, they become fusible, otherwise not. The opals scarcely contain any iron, and therefore are infusible at 168°.

It is remarkable that these stones difficultly give fire with steel, and yet are more difficultly scratched than many that do.

They are often found in a state of decomposition.

Their transitions are into hornstone, jasper, and I believe sometimes into felspar.

4th Family.—Ligniform Opal, or Pitchstone.—Its colour are, milk white, reddish or yellowish white, or yellowish grey, nut or yellowish brown, or ochre yellow, or hyacinth red, or greyish black; these colours are scarce ever single, but generally in different stripes in the same mass.

It occurs in large masses.

Lustre, 2.3, waxy. Transparency, 1.0; seldom, 2.

Longitudinal fracture, fibrous; cross fracture, conchoidal; fragments, oblong.

It will not give fire with steel, and yet can scarcely be scratched. Brittle.

Its specific gravity, from 2,08 to 2,1.

Of Hydrophanes.—Such opaque stones, as become transparent by placing them in water, are called *hydrophanes.* These are for the most part semi-opals or pitchstones, and particularly those that are somewhat withered by exposure to the atmosphere; they generally adhere to the tongue.

Mr. Klaproth, having distilled some of those of Saxony, obtained from them 5 per cent. of water, inflammable matter and air, 93 per cent. of silex, 1 of argill, and no iron*.

Mr. Weigleb's analysis gives pretty nearly the same contents†; but Mr. Mayer found some that contained a larger proportion of argill, and some iron‡, as did Mr. Gerhard ||. It seems also certain that some of these stones attract moisture when exposed to the atmosphere, for, they increase in weight §, and some even burst. Other stones are often hydrophanous, as steatites and calcedony. 2 Bergm. p. 70.

28th Species.—Hyalite, Muller's Glass of the Germans. Lava Glass of many.—Its colour, pure white.

Its lustre, 2.3. Glassy. Transparency, 2.3, rarely, 0. Voight Fulda, 171.

It occurs most frequently in basalt, or trapps; either in grains, or in masses inclining to a rhomboidal form, or in filaments.

Its fracture even, inclining to the conchoidal; but, on the whole, often lamellar.

Hardness, 9. Specific gravity, by my trial, 2,110.

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* 1 Chym. Ann. 1790, p. 52.

† 1 Chym. Ann. 1789, p. 402.

‡ Naturforsch. 19 Stuck. p. 220.

|| 2 Gesch. p. 400.

§ 2 Chym. Ann. 1784, 193.

It is infusible at 150°, but yields to mineral alkali.

By the analysis of Mr. Link it contains 57 per cent. silex, 18 argill, 15 calx, and very little iron; he does not tell us what were the other ten parts.

In composition then it nearly agrees with those stones which Mr. Bergman and others have called zeolites, and I have called ædelites; and yet no one has hitherto considered Muller's glass as zeolite; but many have taken it for calcedony, though it wants the bluish colour of this sort of stone; many also for an opal, but its lustre is very different, and many, particularly when it is rhomboidal and foliated, for felspar, from which, when buried in other stones, it is difficult to distinguish it. Mr. Werner, as I hear, now considers it as a middle thing between opal and calcedony, and calls it hyalite.

It has lately been found in Serpentine, near Swentick, in Silesia; Ferber Briefe, 40. 1 Nose, 251; and therefore cannot be a volcanic production, as many, notwithstanding its infusibility, have supposed it.

29th *Species.—Calcedony.*—Of this species I distinguish two families; common calcedony, or calcedony simply so called, and carnelian.

1st *Family.—Calcedony, or Common Calcedony**.—Its colours are various, but most generally greyish; as yellowish, greenish, bluish, and pearl grey; or bluish white. This last often passes into blue, or violet blue, as the first does into honey yellow, or blackish brown.

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* Werner's Cronst. p. 130.

It is also found *milk white*, and then called *cacholong*, very rarely grass green, or mountain green, or flesh red, or dotted with red; often with many colours in the same piece, either in stripes, or spots, and with arborizations; when the white and black or brown stripes alternate, it is called *onyx*, or *camehuya;* if the white and grey alternate, *calcedonyx*. The grey when they present arborizations are called *mochos*. The blackish or dark brown, being held against a strong light, appear dark red.

It occurs, in amorphous pieces, often flat, oftener blunt, and somewhat rounded, or stalactitic, or in nodules, or cellular, and lately also crystallized in hexahædral or quadrangular pyramids with convex planes, or in hexangular prisms with a pyramidal apex, or even, as is pretended, cubic or rhomboidal*. But some assert that these are only investments of other crystallized stones that have since decayed; or filiform, tubular, or spiky.

The surface of this stone is generally rough and uneven, often tuberose and botryoidal or invested with drusy quartz, yet sometimes even and smooth.

Its external lustre fortuitous. Its internal, 1. Transparency, 2.3, rarely 1.

Its fracture even, often inclining to the conchoidal, more rarely to the splintery. Sometimes intermediate between the even, splintery, and uneven. Fragments, 3. Commonly without any separate concretions, sometimes with thin, or thick, curved, and mostly concentric lamellar distinct concretions.

Its hardness, from 10 to 11. Specific gravity, from 2,60 to 2,665. Mr. Bergman was induced by Muschenbroek to suppose it might extend to 4,36, which is impossible; but it is frequently found much lower than 2,6; namely, when the calcedonies are hydrophanous. Hence Mr. Brisson found one of these 1,0942, and others 2,29. This is the stone called *oculus mundi*. This difference arises only from the small pores into which water cannot penetrate.

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* 1 Chym. Ann. 1785, p. 480. Nov. Act. Petrop. 1785, p. 266.

The blue he found to amount to 2,5867.

It is infusible *per se*, even by a burning glass, but by pure air it is, though with difficulty, converted into a white semi-transparent enamel.

Mineral alkali melts it with effervescence, borax without any, and microcosmic salt scarcely affects it.

By Mr. Bergman's analysis, the calcedony of Feroe contains 84 per cent. of silex, and 16 of argill, slightly contaminated with iron. 2 Bergm. p. 60. By that of Mr. Bindheim, 83,3 silex, 11 calx, 1,6 argill, and a minute portion of iron. 3 Naturforsch. Freunde, p. 429.

It sometimes decomposes by exposure to the air; I have often seen its surface fretted and porous, with an earthy and ochry powder.

Its transitions are into opal, flint, quartz, jasper, crysoprasium, and felspar.

2nd Family.—Carnelian.—Its colours are of various shades of red, from the deep blood red, to the lighter, almost white, or reddish brown, or honey or wax yellow, or yellowish brown, and often these colours or shades occur in the same mass, either in gradation, or stripes, or spots.

Amorphous, or in blunt or somewhat rounded ed masses, with rough or uneven surfaces, or stalactitic.

Its lustre, scarcely 1. Transparency, 3.2.1, often cloudy,

Its fracture conchoidal. Fragments, 3.

Hardness, 10. Specific gravity, from 2,597 to 2, 3.

It is infusible, but loses its colour at 160°, nor even by pure air is it melted as perfectly as calcedony is, nor in a chalk crucible in those parts that touch the chalk as calcedony is. 2 Gerh. Gesch. 10. But by the usual fluxes it is affected nearly as common calcedony.

Some consider it as a compound of jasper and calcedonian.

Some are found partly withered by exposure to the air, particularly the stalactitic.

It sometimes graduates into quartz.

30th Species.—Cat's Eye.—Its colour is generally of a greenish or yellowish grey, or light, or dark yellowish brown, or reddish brown, or striped with these colours; and, in certain positions, particularly when polished, emitting a silvery or yellowish moveable effulgence.

It is found in blunt or rounded fragments, and comes from Ceylon.

Its lustre, 2. Transparency, 3.2.

Its fracture imperfectly conchoidal, sometimes approaching to the splintery.

Fragments, 3. Hardness, 10. Specific gravity, from 2,56 to 2,66.

31st Species.—Flint. Feuer Stein of the Germans.—Commonly of a yellowish, or bluish grey colour; the latter, however, often passes into the greyish black, and the former into the ochre yellow, or brown. Several of these often meet in the same specimen, either in veins, stripes, clouds, or dots.

Amorphous, interspersed in other stones, or in nodules, or rounded lumps, often perforated, very rarely crystallized, in double triangular pyramids; often also forming the substance of petrifactions, particularly of echinites. Its surface generally uneven and wrinkled, either smooth or rough, often covered with a rind, either calcarous or argillaceous. Its external lustre, 0 or 1. Internal, 1. Transparency, 2.1, sometimes nearly 3. Fracture conchoidal, seldom imperfectly. Fragments, 3.

Hardness, from 10 to 11. Specific gravity, from 2,58 to 2,63.

Heated, it decrepitates, whitens, becomes brittle, and opaque, is infusible at 168°, and is barely softened by pure air; the usual fluxes affect it as they do quartz.

The impressions of marine shells, and even of leaves, are frequently found in flints, which leaves no doubt of their having been produced in the moist way, and even that some are of modern formation*.

According to Mr. Weigleb's analysis, they contain about 0,80 silex, 0,18 argill, and 0,02 calx†.

Its transitions are into quartz, calcedony, carnelian, and hornstone.

It is frequently intimately mixed, not only with quartz or calcedony, but even with calcareous earth, or calcareous spar, as may be seen in Leske's Catalogue. Specific gravity, 116.

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* Charpent. Min. Geograph. p. 40, 66. Leske Reise durch Sacks. Ferb. Oryctogr. von Derbysh. p. 16. 1 Naturfor. &c.

† 6 N. Acta. Natur. Curiosa, p. 408.

32nd Species.—Hornstone. Hornstein of the Germans, Petrosilex, Chert.—Its colour commonly dark blue, yellowish, or pearl grey, sometimes yellowish white, flesh, or brownish red, or mountain blue, or blackish brown, or greenish brown, or dark green, or olive green, often variegated.

Amorphous for the most part, but lately found crystallized by Mr. Beyer on Schneeberg, either in hexahædral prisms, some with, some without, a pyramid, or barely rounded at both ends, or in double triangular pyramids, or cubes or hexahædral plates, the surface of these crystals mostly rough and uneven, some hollow, some solid, sometimes as thin as paper *.

Its lustre, 0. Transparency, 1.2. The crystallized, sometimes 0.

Its fracture generally splintery, more rarely conchoidal, sometimes from the fine splintery passing into the even, but of a coarser grain than flint. Fragments, 2.3.

Hardness, from 7 to 9. Specific gravity from 3,532 to 2,653.

Though Mr. Bergman counts this stone among those that are fusible *per se*, even by a blow-pipe, yet, in the many trials I have made in a much superior heat, I found but one which gave any sign of fusion; but most frequently decrepitate and whiten.

1st, The blackish grey, Leske, K. 48, with some mixture of arsenical pyrites, whose fracture is splintery; its specific gravity, 2,744, probably from the pyrites, and opaque, barely concreted at 140°, but shewed no other sign of fusion at 163°.

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* 2 Crell. Beytr. p. 191. 3 Helvet. Maga. p. 251.

2nd, The grey hornstone, Leske, K. 383, whose fracture is fine splintery; its specific gravity, 2,654, whitened and barely coalesced at 148°.

3d, The yellowish white hornstone, Leske, O. 441, whose fracture is fine splintery, and its specific gravity, 2,563, whitened, but gave no sign of fusion at 155°.

4th, A bluish, and partly yellowish grey hornstone, mixed with jasper, Leske, O. 442; its fracture, partly splintery, and partly inclining to the flat conchoidal, whose specific gravity is 2,626, whitened, but did not yield in the least at 151°.

5th, A dark purplish red iron shot hornstone, Leske, G. 61; fracture, fine splintery, and uneven; specific gravity, 2,638, barely agglutinated into a dark grey mass at 147,5.

6th, But a greenish white hornstone, with reddish spots, from Lorraine (given to me by Mr. Woulfe), whose specific gravity is 2,582; fracture conchoidal, semitransparent at the edges; lustre, 0; fragments, remarkably sharp; hardness, 10; whitened, and became brittle at 127°; and at 144°, melted into a semitransparent compact enamel. Mr. Saussure found the hornstones of Switzerland in general infusible; and only those lying in calcareous strata, to be infusible in a high degree of heat.

7th, I found also another hornstone fusible, but it is iron shot, Leske, S. 831; outside it has a brownish red rind, but inside, its colour is bluish grey; its fracture, uneven and splintery;

its specific gravity 2,813. At 146°, it melted into a black compact glass.

The hornstone I formerly analyzed is that mentioned at No. 6. It contained 72 per cent. silex, about 22 argill, and about 6 of mild calcareous earth, or rather more; and, I believe, rather less argill, if this were sufficiently dried. The infusible hornstones probably contain no calx, or less.

Hornstones are frequently found in a state of decomposition.

Its transitions are into flint, calcedony, crysoprasium, jasper, quartz, opal, siliceous shistus, argillite, sandstone, and even into granular limestone, and indurated clay.

Hornstone differs from jaspers, often by its splintery fracture; always by its transparency though imperfect, and want of lustre; from flints, by its fracture, dulness, and hardness; but when its fracture happens to be conchoidal, by its dulness, lesser transparency, and hardness; from quartz, by its dulness and inferior hardness; from serpentine, generally in hardness, specific gravity, and fusibility; from heliotropium, by the aggregate of its properties.

2nd Family.—Shistose Hornstone.—Schiefriges Hornstein. Voight Abhand. p. 81.—Of this I distinguish three varieties; siliceous shistus, lydian stone, and hornslate.

1st *Variety.—Siliceous Shistus, Gemeiner Kiesel Schiefer of Werner.*—Dark bluish grey, or greyish black, mostly intersected with reddish veins from iron. The bluish grey often intercepts a whitish earth between its laminæ. Lustre, 0. Transparency, 1, or 0.

Fracture, in the gross, slaty; of the single plates, fine splintery. Fragments, 2.3.

Hardness, from 9 to 10. Specific gravity, from 2,596 to 2,641, by my trial.

The greyish black, Leske, O. 601, whose specific gravity was 2,641, became grey when heated, but was not otherwise altered by a heat of 156°. The bluish grey, Leske, O. 602, whose specific gravity was 2,596, grew whiter, coalesced, but did not melt at 141°.

The greyish black is that which was analyzed by Mr. Weigleb, as it seems (though he calls it coal black), and found it to contain 0,75 silex, 0,10 calx, 0,046 magnesia, 0,035 iron, and 0,052 inflammable matter, which appears to be genuine coal*.

This stone cannot be the slaty petrosilex mentioned in 2nd Saussure, as it contains no argill.

Its transitions are into quartz, hornstone, argillite, and coticular slate. Sometimes it is so mixed with argill as to seem to pass into it, as in Leske, G. 154.

It seems to be nothing more than a slaty, and at the same time rifty, hornstone; the rifts lined with calx of iron.

2nd Variety.—Basanite. Lydian Stone of Werner. Black Jasper of some.—Its colour, dark greyish black, frequently intersected with veins of quartz.

It is generally found in blunted fragments in the beds of rivers.

Lustre, scarcely 1. Transparency, 0.

Fracture mostly even, sometimes inclining to the conchoidal. Fragments, 3.

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* 1 Chym. Ann. 1789, p. 50, 140.

Hardness, 10. Specific gravity, 2,596.

When pounded, its powder is black.

Heated to 164,5°, it remained black, and shewed no sign of fusion.

3d Variety.—Hornslate, of Charpentier and Voight. Shistose Porphyry of Werner.—Its colour is *grey*, of different shades, from the ash, to the bluish, or olive green. As this *grey* consists of two colours, the white and blue, the stone itself is looked on by Mr. Werner as an aggregate, and the white he considers as denoting felspar; and hence he calls it a porphyry; and, because it is slaty, shistose porphyry. However, the felspar is often so minute, that it can scarce be distinctly perceived; and in such cases the stone may be placed here, and not among aggregate stones, and may be called hornslate.

In the *bluish* the distinction of blue and white is most perceptible.

Generally amorphous, and in large masses, sometimes columnar.

Its lustre, mostly 0; yet in a strong light a few shining particles may sometimes be perceived. Its transparency, 1.0.

Its fracture, on the whole, slaty, but of the single laminæ, which are often very thick; the fracture is uneven, splintery, and sometimes approaching to the conchoidal.

Its fragments, 2.3. Hardness, nearly 10. Specific gravity, from 2,512 to 2,700, by my trials.

The specimen in Voight's Catalogue, marked 55, and in Leske's, S. 645, which is ash grey; and whose specific gravity is 2,5122, melted at 145°, into a dark grey, almost compact enamel.

The specimen, Leske, S. 937, which is bluish grey, and in the form of a quadrangular prism, its specific gravity, 2,693, melted at 166o, into a greenish yellow spongy mass.

By Mr. Weigleb's analysis, the ash grey, Voight 55, contains 0,73 silex, 0,239 argill, and 0,035 iron *.

As the term hornslate, or *hornshiefer*, has been applied to various sorts of stones, Mr. Hoepfner, of Switzerland, generously offered a premium to the person who should clearly ascertain its present signification: satisfactory answers were accordingly given by Messrs. Kärsten and Voight. By these it appears,

That *Wallerius* applied this name to hornblende slate, or shistose hornblende.

Ferber, partly to micaceous argillite, and partly to shistose mica, in which he is followed by Baron *Born* and *Haidinger*.

Leske, in his voyage through Saxony, often calls our stone *horn porphyry*.

Werner first called it as Charpentier and Voight do, but afterwards bestowed this name on lydian stone, as some others had done before him; but now he drops this name entirely, and calls our stone shistose porphyry. See Leske, S. 1763, and 1811.

It seems also the stone mentioned. 2 Saussure § 672, is our hornslate.

The bluish grey often passes into trapp, or basalt, or into argillite, as in Leske, S. 1639.

Its chief distinction from siliceous shistus consists in its fusibility.

33d Species.—Jasper.—Of this species I distinguish four families, common jasper, Ægyptian pebble, striped jasper, and sinople.

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* 1 Chym. Ann. 1787, p. 302.

1*st Family.—Common Jasper.*—Its colours are milk white, or greyish white, or yellowish white, citron, Isabella, honey or ochre yellow, brownish yellow, brick, cochenille or blood red, brownish dark red, yellowish or reddish brown, liver brown, or blackish brown, or olive, canary, or dark green (blue or black it seems have not occurred*); or variegated, spotted or veined with many of those.

It is met with either in large masses, or blunt detached fragments. Mr. Gerhard tells us, he has found some irregularly crystallized, in hexahædral prisms, among the fossils sent to him by Mr. Beyer from Schneeberg. Gerh. Grundriss, 285. And Baron Born mentions some found in the Palatinate. 1 Raab. 126.

Its lustre, 2.1. Its transparency 0, or nearly 1.

Its fracture, conchoidal, sometimes imperfectly, sometimes flatly. Fragments, 3.

Its hardness, from 9 to 19. Specific gravity, from 2,58 to 2,7. Mr. Brisson, indeed, mentions some whose specific gravity is but 2,358, and others, whose density extends to 2,76 or 2,8; but, as he tells us, jasper scarce ever discovers any lustre in its fracture, it is probable he does not always comprehend in his idea of jasper, the stone here described. The heavier sort seems evidently contaminated with metallic particles.

It does not decrepitate when heated; nor in my experiments did it harden. The dark cochenille red, mixed with brick red, Leske, O. 822, whose specific gravity was 2,6288, and its hardness 10, being heated to 157,5°, gave fire more weakly, and thence seemed less hard, lost its colour, having turned to greyish black, and shewed no sign of fusion. Another specimen of a lighter red, somewhat mixed with quartz and calcedony, whose specific gravity was 2,597, being heated to 156°, acquired the same colour as the former, did not harden, nor in the least incline to fusion. Alkalis and microcosmic salt difficultly flux it; borax better, and without effervescence.

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* That mentioned by Lasius, Hartz, 106, seems not to be true jasper, its specific gravity being only 2,069.

Even by pure air jasper is scarcely, and but imperfectly, melted, as appears by the experiments of Mr. Lavoisier. It discovers no metallic mixture; its colouring matter is rather volatile; and its low specific gravity shews it contains no iron. As, however, Mr. Gerhard found it to yield in a chalk crucible, in the parts that touched the chalk, it is probable it contains a small portion of argill, with a much larger of silex. Unless very impure, it does not wither by exposure to the air.

Its transitions are into hornstone, opal, argillite, and lithomarga; it is often intimately mixed with calcedony.

The liver brown stone of Leske, O. 836, being destitute of lustre, I reckon a hornstone. No. 817 O. of Leske, is by Kärsten reckoned a jasper, yet it has all the appearances of pitchstone; its specific gravity is only 2,442, which marks it decisively a pitchstone.

2nd Family.—Ægyptian Pebble.—This stone presents various colours together in the same specimen, either in regular, or irregular concentric and alternating stripes, or layers, or in dots and dendritical figures. The most usual colours are the yellowish, and liver brown, reddish brown, Isabella yellow, yellowish grey, greyish, or reddish white, milk white, leek green, and black; this last only in dots and dendritical figures. It is found in spheroidal, or flat rounded masses, which are inveloped in a coarse rough crust.

Its internal lustre, 1. External, 0. Its transparency, 0.

Its fracture conchoidal.

Its hardness, 10. Its specific gravity, 2,564. Brisson.

Found principally in Ægypt, sometimes in Europe, particularly in Lorraine.

3d Family.—Striped Jasper. Band Jasper of Werner.—This stone also presents different colours in the same specimen, generally in straight, more rarely in curved concentric stripes or layers. Seldom in oblong spots.

The most usual colours are yellowish, or greenish grey, ochre, and Isabella yellow, brownish red, pale or dark flesh red, mountain or dark green.

It occurs in large masses. Lustre, 0. Transprency, scarcely I.

Its fracture imperfectly conchoidal, or nearly even.

Its hardness, from 9 to 10. Specific gravity, from 2,5 to 2,82.

4th Family.—Sinople.—Its colour dark red.

Its lustre, 0. Transparency, 0.

Its fracture, imperfectly conchoidal.

Its hardness, from 9 to 10. Specific gravity, 2,691. Brisson, p. 120.

It is said to contain 18 per cent. of iron. 1 Raab. p. 125. Yet, if so, it should be much heavier.

A red hornstone is sometimes known under this name in Hungary.

34th Species.—Porcellanite, Porcelain Jasper of Werner.—Its colours are pearl grey, lavender blue, pale blue, pale yellow, greenish yellow, brick red, with pearl grey, or greyish black*.

It is found in large masses, frequently rifty.

Its lustre, from 1 to 2. Transparency, 0.

Its fracture, imperfectly conchoidal, inclining to the even. Fragments, 2.3.

Its hardness, 9. Its specific gravity, 2,33, by my trial.

The specimen of Leske, K. 33, melted at 151°, into a spongy, yellowish grey tumefied semi-transparent mass. Hence I consider it as specifically different from jaspers. The colour of that I employed was lavender blue, and seemed perfectly pure.

Mr. Peithner called it porcellanite, which name should be continued, not to confound this stone with genuine jaspers.

35th Species.—Heliotropium.—Its colour is generally intermediate between grass and leek green, sometimes dark mountain green, sometimes lighter, or approaching to a blackish green, and mostly dotted or spotted with olive green, ochre yellow, or blood red spots of jasper.

Amorphous.

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* 1 Bergbau. p. 358.

Lustre, 1.0. Transparency, 2.1, sometimes scarcely 1.

Its fracture conchoidal, sometimes flat or imperfect, or mixed with the coarse splintery.

Fragments, 3.

Its hardness, from 10 to 11. Its specific gravity, 2,62 to 2,7.

In Mr. Lavoisier's experiments, it was scarcely melted even by pure air. In mine the dark green of Leske, O. 580, whose specific gravity was 2,681, became reddish brown at 114°; at 142°, its fragments slightly agglutinated.

This species is evidently nearly allied to jasper, and often differs only by the aggregate of its properties; its fragments sharper, and its transparency often much greater.

*36th Species.—Woodstone. Holzstein of Werner. Lithoxylon of others**.—Its colour is generally blackish, or bluish grey; the former frequently passes into the greyish black, and the latter into the greyish white; and this, from the light reddish grey, into the blood or cochenille red. Seldom ochre yellow, or mountain green; sometimes reddish, or yellowish brown.

These colours most commonly appear together, in spots, blotches, or stripes, in the same specimen.

It always manifests its pristine state, either by its branchy form, or its knots or roots. Its surface, like that of the wood from which it originates, sometimes rough, sometimes uneven, sometimes coarsely streaked in the direction of its length.

Its internal lustre, 1. Its transparency, 1.2.

Its fracture, conchoidal; sometimes imperfectly,

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* Bergm. Journ. 1788, p. 289.

fectly, or approaching to the fine splintery, sometimes slaty; and generally by its interlaced fibrous structure, discovers its origin. Its fragments, 3. Often splintery.

Its hardness. 10. The specific gravity of different specimens which I tried extended from 2,045 to 2,675.

It is commonly (not always) the substance of petrified wood. A stump of a tree six feet in length, and as many in diameter, with roots and branches thus petrified, was lately found near Chemnitz, in Saxony.

It often withers by exposure to the amo sphere.

Its transitions are into quartz, calcedony, and, as some say, into pitchstone or opal.

37th Species.—Elastic Quartz.—Its colour is greyish white, covered with thin scales of grey, or brownish mica.

Its lustre, 0, or 1, from a few micaceous particles dispersed through it. Transparency, 1.

Its fracture I could not well discern, as I was not at liberty to break the specimen; but from a small accidental fracture, it seems earthy.

Its hardness, 9. Brittle. Specific gravity, according to Mr. Gerhard, Mem. Berl. 1783, p. 107, is 3,750; but his stone must be very different from that possessed by the Royal Irish Academy; the specific gravity of this being only 2,624.

Flexible and elastic in a moderate degree in every direction.

Phosphoresces when scraped with a knife in the dark.

According to Mr. Gerhard, it is no way altered by a heat of 140°; but by fixed alkalis

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it is easily fusible. According to Mr. Ehrman, it is by the heat of pure air converted into a semi-transparent glass. But Mr. Gerhard tells us, he exposed his to that heat for seven minutes without any effect.

By the analysis of Mr. Klaproth it contains 0,965 silex, 0,025 argill, and 0,01 iron.

By that of Mr. Gerhard, 0,92 silex, 0,03 argill, 0,02 calx, and 0,01 iron.

Baron Trebra found a flexible sandstone in Thuringia.

38th Species.—Felspar.—Of this fossil there seems to be three families; common felspar, moonstone, and continuous felspar.

*1st Family.—Common Felspar, or Felspar simply so called**. *Spath fusible of Desmaretz, Spath Etinulant, Spathum Pyromachum.*—Its colour is most commonly flesh red, sometimes bluish grey, oftener yellowish white, or milk white, or brownish yellow, rarely blue, or olive green; and lately, in one instance, black. 2 Sauss.

Amorphous and interspersed, sometimes crystallized in rhomboids, or six or eight sided prisms; seldom right angled; very seldom in pellucid needles, tables, or polygons.

Its lustre when broke across, 0; in other directions, 2.3.1. Its transparency, 2.1.

Its fracture discovers a straight foliated texture. The lamellæ polished, and shining often on four sides, cross fracture uneven.

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* This name seems to me derived from *fels*, a rock; it being commonly found in granites, and not from *feld*, a field: and hence I write it thus, felspar.

Its fragments rhomboidal, or tending to that form.

It generally presents granular distinct concretions, either large or small.

Its hardness, from 9 to 10. Its specific gravity, from 2,437 to 2,600; the greenish seem to extend to 2,70.

The yellow felspar of Port François, in North America, is so brittle as not to bear the slightest friction; when heated it becomes red. 31 Roz. Journ. p. 156.

When heated, the crystallized frequently decrepitate, a quadrangular prism of crystallized felspar of Baveno, of a reddish white colour, and whose specific gravity was 2,437, melted at 130°, into a grey semi-transparent porous glass, and at 154° into a compact semi-transparent glass. Another from Silesia, which was not crystallized, and whose specific gravity was 2,554, and of a grey yellowish white colour, melted at 119°, into a grey, smooth, almost compact, semi-transparent glass; and being mixed with an equal weight of Carrara marble, it melted at 105°, into a white opaque, almost compact mass of a silky lustre. The green becomes pale reddish when heated.

Alkalis flux this stone with great difficulty; microcosmic salt (and particularly borax) is more effectual.

According to Mr. Gerhard, the purest felspar found in granites contains 0,46 silex, 0,30 argill, and 0,06 calx. Here 0,18 parts are missing, a loss too great to be imputed to the escape of air and water. Mem. Berl. 1783, p. 119.

Mr. Weigleb, in 100 parts of the reddish felspar of Geyer, found 65 silex, 32 argill, 1,66 calx of iron, and 0,0062 of fluor acid.

1 Chym.

1 Chym. Ann, 1785, p. 392. This compound I found infusible at 155°, therefore it could not form a felspar.

Mr. Heyer, in white felspar, detected 0,74 silex, 0,30 argill, and a minute portion of iron; the amount exceeds 100. In a red felspar he found 0,64 silex, 0,31 argill, 0,06 of iron, and a minute portion of calx. 2 Chym. Ann. 1788, p. 147. Both these compounds are infusible at 150°.

Mr. Meyer, in *white felspar,* 0,74 silex, 0,24 argill, 0,06 calx, and 0,01 of iron; and in red felspar, 0,79 silex, 0,16 argill, 0,023 of iron. These compounds I found infusible at 145°. Mr. Saussure, from a semi-transparent greenish *felspar,* separated 0,43 silex, 0,37 argill, 0,017 calx, and 0,04 of iron. This compound is also infusible at 145°.

Not one of these results exhibits a fusible compound; or, at least, one that would yield a white or grey semi-transparent enamel.

I found crystallized reddish white felspar, whose specific gravity was 2,542, to contain 0,67 silex, about 14 argill, 0,11 of barytes, and 0,08 magnesia. Though this result seems less improbable, abstractedly considered, than any of the foregoing, yet Mr. Dolomieu thinks I must have been mistaken, as (according to him) barytes cannot exist in the felspar of granites, and no other analysis had discovered it. Mr. Hoepfner, however, discovered barytes in granite. 1 Chym. Ann. 1788, p. 134. And, shortly after, Mr. Hassenfratz, in the felspar of St. Yrieux, found 0,70 silex, 0,12 argill, 0,09 magnesia, and 0,08 of barytes. 14 Ann. Chym. p. 14. Mr. Westrumb also found baroselenite in the purest felspar.

Magnesia was indicated in felspar by Mr. Bergman, Sciagr. §. 130. Though not found by many of the subsequent analysts, it did not, however, escape Mr. Monnet, who found it jointly with silex, argill, and calx, in the felspar he examined. 13 Roz. Suppl. p. 54. Nor Mr. Chaptal, who observed it to exist in greater plenty in the red than in white felspar.

Mr. Fabroni, who, happily for Italy, has lately directed his attention to mineralogy, discovered, in the felspar of Ægyptian granite, 0,55 silex, 0,36 argill, 0,02 barytes, 0,04 magnesia, and 0,03 of iron. See Mr. De La Metherie's late edition of the Manual of Mr. Mongez.

Mr. Scopoli, in felspar of Baveno, found 0,63 silex, 0,17 argill, 0,06 magnesia, 0,02 calx, and 0,07 of iron, loss 0,05. With respect to iron, it is highly improbable that this felspar, which is of the purest kind, should contain any. That which appeared may most probably be ascribed to the Prussian alkali he employed in the analysis.

From these different analyses it appears that any compound of silex and argill, in which silex predominates, and to which a sufficient but smaller proportion of calx and magnesia, or of calx, magnesia, and barytes, is added to render the whole fusible in a heat not exceeding 140°, *may* form a felspar, and will undoubtedly be so called, if at the same time it presents a foliated texture; but iron appears to be a foreign ingredient.

The felspar, both in granite and porphyries, is frequently found, or at least suspected to be the part that is found, in a decomposed or disintegrated state, and is said to constitute in such cases, when free from iron, a porcelain clay. But as this clay is infusible, whereas felspar is essentially fusible, and as some felspars are not in the least injured by exposure to the air, it should seem that the stones, so disintegrated as to be converted into porcelain clay, were not originally felspars, but some other species of stone. I do not, however, deny, that in the neighbourhood of volcanos, real felspars may be converted into porcelain clays by vitriolic fumes, as the salts that have magnesia or calx for their basis, may be washed away.

Felspar may also be decomposed when mixed with iron, or when its texture is loose, but then the resulting clay will not be fit for porcelain. To remove all doubt, I separated part of the white earth of a decomposed felspar, Leske, O. 907*, and found it refused to melt at 130°, but formed a porous white enamel at 140°. Hence it is really an earth from felspar, though not true porcelain earth.

Its transitions are obscure, and difficultly traced, but seem to be into shorlites, calcedony, quartz, Labradore stone, Labradore hornblende, and, perhaps, into pitchstone. By disintegration it passes into clay.

*2nd Family.—Moonstone, Adularia of Pint**. —Its colour white, yellowish, or greenish white, somewhat iridescent, sometimes reddish. Found either in blunt amorphous masses, or crystallized either in truncated rhomboidal prisms, single or coalited, or in rectangular tables, or in hexahedral prisms bevilled at both ends, single or reunited. The surface often sulcated.

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* Wern. Cronst. p. 181. 24 Roz. p. 262. 1 Bergm. Journ. 1790, p. 272.

Its external lustre pearly, 3. Its internal the same. Transparency, 2.3.

Its fracture straight foliated, and sometimes appears striated. Fragments, 2. Polished on four sides, and rhomboidal. Its hardness, 10. Its specific gravity, by my trial, 2,559.

At 130° it melted into a white semitransparent mass, with a vitreous surface; but internally between a porcelain and an enamel.

By the analysis of Mr. Westrumb, it contains 0,625 silex, 0,17 argill, 0,065 calx, 0,02 baroselenite, 0,06 magnesia, 0,014 iron, and 0,0025 of water. 2 Chym. Ann. 1790, p. 221.

Another specimen, less transparent, and somewhat yellowish, afforded him 0,63 silex, 0,19 argill, 0,06 calx, 0,0325 magnesia, 0,04 calx of iron, 0,015 baroselenite, and 0,005 water.

Mr. Morell, in another specimen, found 0,62 silex, 0,19 argill, 0,11 selenite, 0,055 magnesia, and 0,0175 water. 2 Helv. Mag. p. 95. Neither of these analysts found the sparry acid.

3d Family.—Continuous Felspar. Felspar en Masse.—Its colour reddish grey, or pale reddish yellow, or flesh coloured.

It is found in large masses, and generally mixed with mica or hornblende, and sometimes forms the basis of porphyries.

Its lustre, 0. Its transparency, 1.

Its fracture, unequal and earthy, sometimes fine splintery. Fragments, 2. Indeterminate, and without any polish.

Its hardness, 10. Its specific gravity, 2,609, in the specimen I tried.

It frequently consists of granular concretions, easily separable.

A specimen of this sort, Leske, G. 233, melted at 150° 5, into a porous porcelain mass, glazed on the surface.

It seems to be the stone called earthy felspar, 2 Sauss. p. 136, 322, and 596.

It differs from the amorphous stones of the first family in this, that the last has a foliated texture, and more lustre, and the fragments tend more to the rhomboidal shape; and also in fusibility.

*39th Species.—Labradore Stone. Labradore Felspar of Werner**.—Its colour is of a light or dark grey, or bluish, or blackish grey; but, in certain positions and spots, reflecting blue, purple, red, green, &c.

In blunted fragments it chiefly occurs.

Its lustre, 2.3 Its transparency, 1.2.3.

Its fracture straight foliated.

Its fragments, 2. Rhomboidal, with four polished faces, or tending to that shape.

Sometimes without distinct concretions; sometimes with large or coarse grained, rarely with thick lamellar.

Its hardness, 10. Its specific gravity from 2,67 to 2,6925.

At 130°, a specimen of the bluish grey, whose transparency was barely 1, and its specific gravity, 2,672, which I had from Mr. Woulfe, was barely glazed on the outside; and at 155° the white part separated itself from the brown, and was melted. The brown was also imperfectly melted into an opaque porous brown porcelain.

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* Wern. Cronst. p. 149.

From this difficult fusibility, I conclude Labradore to be specifically different from common felspars; the nature of the brown matter is not known, this stone having never been analyzed.

The green felspar of Siberia, described by Mr. Bindheim, 5 Berl. Beob. p. 107, is evidently a variety of this species. It differs only in the following particulars. Its colour is apple green, and from that passes into the verdigris green, with white stripes. Its lustre is often pearly and iridescent. 2 Chym. Ann. 1792, p. 234.

Its specific gravity, 2,583; in every other respect it resembles the above. When heated it loses its green colour, hardens, becomes flesh red, but refuses to melt before the blow-pipe. Nor have the usual fluxes much effect on it. Hence I consider both as specifically different from common felspar and its varieties.

Mr. Bindheim found 100 parts of it to consist of 69,5 silex, 13,6 argill, 12 gypsum, 0,7 calx of copper, 0,036 calx of iron, and about four grains were lost. 5 Berl. Beob. p. 111.

*40th Species.—Petrilite, or Cubic Felspar of Kärsten**.—Its colour is reddish brown, or brownish red.

Amorphous.

Its lustre, 2. Its transparency, partly 2, partly 1.

Its fracture participates of the splintery and foliated; but inclines more to the former.

Its fragments, 2; cubic, or inclining to that form, and without polished faces.

It seems to consist of thick indistinctly separate straight lamellar concretions.

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* 2 Bergm. Journ. 1788, p. 809.

Its hardness, 9. Brittle. The specific gravity of the specimen I tried, which was that in Leske, O. 907^c, was 3,081.

At 160°, it whitened, and barely concreted, without any farther sign of fusion.

Hence it is plain it is specifically different from the other stones hitherto called felspars; on this account, to avoid confounding it with them, I call it petrilite

41st Species.—Felsite, or compact Felspar of Widenman[*].—Its colour is azure blue, or in some parts bluish white, or pale, or deep brownish, or blackish green, or greenish white.

It is found amorphous, associated with quartz and mica; in larger or smaller masses in granite; the green chiefly in porphyries. The blue was lately discovered near Krieglach, in Stiria, by Mr. Widenman.

Its lustre, 1. Its transparency, scarcely 1.

Its fracture uneven, yet often approaching to the fine splintery; in some specimens a fine foliated texture may, though with some difficulty, be perceived.

Its fragments, 2. Indeterminate.

Gives a white streak.

Its hardness, 9. Its specific gravity not considerable, that is, does not amount to 4.

Exposed to a blow-pipe it whitens and becomes rifty, but is infusible *per se*.

This stone I have not as yet seen, or at least distinguished.

42nd Species.—Argentine Felspar, or Oculus Piscis[†].—Its colour white, two opposite faces silvery white, two others dead white, or yellowish; when decomposing iridescent, when farther decomposed ochre yellow.

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[*] 1 Bergm. Journ. 1791, p. 345. And the note in p. 346.

[†] 37 Roz. Journ. p. 49. 36 Roz. Journ. p. 405.

It is found amorphous in rounded fragments, or crystallized nearly as common felspar, or in detached plates, or in shining striæ.

Its internal lustre, 4. Its transparency, 2; or 1, when decomposing.

Its fracture in one direction foliated, in another striated.

Its fragments rectangular. The lamellæ inflexible.

Hardness of the silvery laminæ, 6; of the others, 9. Brittle. Specific gravity, when not much decomposed, 2,500; when more advanced in this respect 2,300 or 2,212.

When decaying, if breathed on, it gives an earthy smell.

Exposed to the blow-pipe, and stuck on glass, if the flame be directed to the edges, it easily melts into a clear compact glass; but, if the flame be directed on the faces, they still preserve their lustre, and only the edges slowly melt.

This stone was discovered in the black mountain of Languedoc, by Mr. Dodun, one of the most eminent French mineralogists; by its external characters it is nearly allied to common felspar, but, by the quantity of calx of iron which it essentially contains, it must be deemed specifically different from it.

By the analysis of Mr. Dodun it contains 0,46 silex, 0,36 argill, 0,16, calx of iron.

43d Species.—Of the Redstone of Rawenstein.—This stone is thus described by Count Razoumouski. 3 Mem. Lausanne, p. 129.

Its colour, by reflected light, is rose red, and somewhat iridescent; by refracted, blue.

It is found amorphous, and in large masses

Its lustre, 2; Its transparency, 2.3.4. Its fracture thick foliated.

Its fragments tending to the cubical form. Consists of numerous distinct concretions.

Its hardness from 9 to 10. Brittle. Its specific gravity, considerable, approaching to that of baroselenite.

It decrepitates when suddenly heated, and in the strongest heat of a smith's forge it melts but imperfectly. The usual fluxes have no very sensible effect on it.

It seems nearly allied to petrilite.

44th Species.—Siliceous Spar. Saulen Spath of Bindheim.—Its colour white, straw yellow, or sea green, mountain green, or light blue. Red?

Its lustre silky, 2.

It is found crystallized in quadrangular or hexangular prisms, transversely streaked, and generally heaped together.

Its fracture fibrous, or striated.

It effervesces with acids.

According to the analysis of Mr. Bindheim, it contains 61,1 silex, 21,7 calx, 6,6 argill, 5 magnesia, 1,3 calx of iron, and 3,3 water. 3 Schrift. Naturforsch. Freunde. p. 452.

The description above given is imperfect; yet from that, and the analysis, we may infer that it is nearly allied to zeolites. Mr. Bergman indeed* considers it as of the same species as the zeolite of Hællestadt; but the small proportion of water it holds discriminates it too strongly from that fossil, to allow them to be of the same species.

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* Schwed. Abhand. 1784.

Mr. Hoffman, on the contrary, conjectures it may be the same as the *tremolite* of Hœpfner, which Mr. Fenber[*] informs us is of a *red* colour, and fibrous, or striated, and in which Mr. Klaproth found 0,65 silex, 0,18 calx, 0,103 magnesia, 0,065 fixed air and water, and 0,005 calx of iron. 1 Chym. Ann. 1790, p. 54[†].

Of Agates.—Agates, as Mr. Werner justly remarks, do not form a distinct species of stone, but consist of quartz, crystal, flint, calcedony, amethyst, jasper, carnelian, heliotropium, jade, aggregated in binary, ternary, or more numerous combinations, and susceptible of a good polish; even one of these, if it presents two or more colours and assumes a good polish, is called an agate. These mixtures present either dots, veins, zones, filaments, figures of various kinds, ramifications, or arborizations.

They are found either in rocks, as in Saxony, near Kunmersdorf, or in angular fragments, or in nodules, or contained in small rounded lumps called *geods*, or, though seldom, stalactitic.

Their colours are, the clear yellowish, reddish, milk, or greyish, or bluish white, or pearl grey, or honey, ochre, or orange *yellow*, flesh, blood, or brick *red*, or reddish *brown*, violet *blue*, or brownish *green*.

The clear pellucid
white denotes Crystal or quartz,

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[*] Drey Briefe Miner. Inhalt. p. 21.

[†] 1 Bergm. Journ. 1790, p. 82.

The yellowish white denotes	Amethyst, calcedony,
The greyish white	Quartz,
The milk white	Jasper, amethyst,
The yellowish grey	Quartz, flint,
The smoke grey	Calcedony, flint,
The pearl grey	Calcedony,
The greenish grey	Calcedony, jasper,
The bluish grey	Calcedony,
The honey yellow	Flint, jasper,
The yellow	Jasper,
The ochre yellow	Calcedony,
The orange yellow	Calcedony,
The yellowish brown	Carnelian,
The reddish brown	Hornstone, carnelian,
The flesh red	Carnelian,
The blood red	Jasper, carnelian,
The brick red	Jasper,
The violet blue	Amethyst,
The brownish green	Heliotropium,
The leek green, and feeling somewhat greasy	Jade.

Amethysts are distinguished also by their distinct columnar concretions.

The figures contained in agates are various, some representing the polygon lines of a fortification, some perspective views, or arborizations, or moss, and called mochos; some contain real moss, or other herbs, as Mr. D'Aubenton has shewn. Mem. Paris. 1782, p. 668.

The specific gravity of agates is generally from 2,58 to 2,666. If they contain jade they may be heavier. Their hardness from 10 to 12.

The finer kinds are called oriental, they are semi pellucid.

SIXTH

SIXTH GENUS.

Stronthian Earth.—1st Species.—Combined with fixed air, Stronthianite.—Its colour is light, or whitish green.

It is found in large shapeless masses.

Its lustre, from 2 to 3. Its transparency, 2.

Its fracture, thick striated, sometimes presenting distinct columnar concretions.

Its hardness, 5. Its specific gravity, from 3,4 to 3,644.

It burns to lime in a heat of 140°, and easily vitrifies with the clay of the crucibles.

It effervesces with the nitrous and muriatic acids, and forms with them easily crystallizable salts, but which are precipitable by barytic lime water.

SEVENTH GENUS.

Jargon. Zircon of the Germans.—The only species, of this genus hitherto known, is the stone called jargon of Ceylon, or Zircon, which exhibits the following characters*.

Its colour is grey, or greenish white, mountain or olive green, inclining more or less to yellow, yellowish brown, reddish brown†, and violet.

It is found either in small irregular grains, or crystallized. The crystallization presents either right-angled quadrangular prisms surmounted with pyramids; or octohædrals, consisting of double quadrangular pyramids; the surface somewhat smooth and polished.

The external lustre is casual, but the internal is strong and inclining to the metallic.

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* 4 Lempe Magaz. p. 99. 2 Berl. Beob. p. 147.

† Brisson, p. 73.

The fracture is intermediate between the thin curved foliated, and the flat conchoidal, and some small-grained distinct concretions.

The fragments, indeterminate and very sharp.

Strongly semi-transparent. Sometimes opaque. Brisson, 73.

Its hardness, from 10 to 16. Its specific gravity according to Brisson, 4,416. And according to Mr. Klaproth, 4,615. According to Werner, 4,7. 2 Bergm. Journ. 1790, p. 90.

Heated to redness, and quenched in water, it becomes rifty, and troubled.

According to Mr. Geyer, it is scarcely fusible, even by the help of pure air.

It is insoluble in acids, except by particular management.

By the analysis of Mr. Klaproth *, 100 parts of it contain 31,5 silex, 5 of ferruginous nickel, and 68 of a new earth.

EIGHTH GENUS.

Sydneia.—Of this no species has as yet been found; nor has it been detected in any other stone.

NINTH GENUS.

Adamantine Earth.—1*st Species.*—*Adamantine Spar.*—This earth hath hitherto been discovered only in adamantine spar, though its existence may be suspected in some felspars.

Of this stone we are acquainted with three varieties; the first is found in China; the second in India, near Bombay, and there called *corundum;* and the third, in France.

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* Brisson, p. 73.

1st *Variety*[*].—Its colour is grey, with various shades of brown, or green.

Its form, when most regular, is that of an hexangular prism, two sides large and four small (Brisson), without any pyramid. Its surface somewhat striated, and covered with a rind of silver white mica, with here and there particles of red felspar, and sometimes with sulphur pyrites.

Its internal lustre, when broken crossways, 0, or 1; diagonally, 3.

Its fracture, more or less, perfectly foliaceous, and sparry.

In thin pieces, and at the edges, semi-transparent.

Its hardness, 15. Others say it is a little harder than crystal. 30 Roz. p. 13. Brittle.

Its specific gravity, according to Klaproth, 3,710; according to Brisson, 3,8732.

Some grains of crystallized magnetic iron are disseminated through it, which are easily separated by a magnet when the stone is pulverized. They amount to about one-fifth of the whole.

It is infusible in a porcelain heat, and Mr. Lavoisier found it so even by pure air; yet Mr. Ehrman assures us, he melted it into a dark brown button spotted with white in one minute. 2 Chym. Ann. 1788, p. 143.

2nd Variety.—This differs from the former only in this, that it is whiter, its texture more manifestly foliaceous; and that the ferruginous particles barely adhere to it, and are not dispersed through it.

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[*] 2 Berl. Beob. p. 295.

3d Variety.—This was found by Mr. Morveau, in Poitou. Its colour reddish brown, and its hardness superior to that of crystals. Its specific gravity was 4,183. 1 Ann. Chym. p. 188. Hence he presumes it to be adamantine spar.

After these we may perhaps place the heavy felspar mentioned by Mr. Brisson, called in Rome, *Verdi di Corsica Duro ;* its colour is dead white, with large blotches of green, and its hardness extraordinary. Its specific gravity, 3,105. And another, mentioned by Mr. Morveau, found in Le Forez, of great hardness, whose specific gravity was 3,075 ; but as it yielded a little to the heat of a furnace, it is probable it contained some mixture of common felspar.

CHAP. XI.

OF AGGREGATED STONES.

THESE consist of either grains (angular masses) of stones simply compacted together, and forming either uniform or slaty masses; or of stones of one or more species, inhering in another stone, which may be considered as their basis or cement; or of rounded stones of different sorts, adhering to or inhering in some other; or of masses of different aggregates inhering or adhering to each other. All these, though susceptible of infinite variety, might at least, in general, be distinguished by appropriate names, if a classification were now for the first time to be attempted; but unhappily various combinations have already been denoted by particular names, under which they are now known to mineralogical writers, so narrowed and restrained in their signification as to be incapable of being brought under general divisions; and to introduce new names would produce confusion. Hence I shall confine myself to the explanation of the denominations already in use, as they are understood and applied by the most exact writers on this subject.

Granite.—This name in the strictest sense denotes an aggregate of quartz, felspar, and mica; all in very variable proportions, not only in different, but often in the same mountain; the felspar generally amorphous, seldom crystallized, very frequently in the greatest proportion, and the mica in the least.

Ths size of the grains is also variable, from that of a pin's head to that of two or three feet; but this last is very rare*. 2 Bergm. Journ. 1789, 932. The largest usual size is that of a nut. Some are so small as not to be distinguished without a strong lens, and are often taken for simple stones. See Voight, *Ilmenau*, 29.

The colour of granites is infinitely diversified; it depends chiefly on that of the felspar, this being generally the most copious ingredient; this is generally reddish, more rarely greenish, or bluish, or greyish; the mica more generally black, more rarely yellowish or grey; the quartz commonly greyish white.

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* Renovanz, 7.

Granites are most commonly very hard; some, however, inclining to disintegration are very brittle.

The felspar found in granite, though generally of the common kind, yet may be of the sorts I have called petrilite or felsite.

Hence the specific gravity of granite is variable, from 2,5388 the lowest I have met with, to 2,9564, that of the blue granite of Carinthia, which Brisson tells us is the most beautiful of the species. Here the felspar is blue, and most probably the compact felspar of Weidenman, which I have called *felsite*. But the most usual specific gravity of granites is from 2,56 to 2,66 or 2,76, if we admit that it may contain a small proportion of shorl, or rather hornblende, which Brisson constantly mentions; he may, however, mistake ferruginous or black mica for this. That of the red Ægyptian granites, of the obelisks of Rome, is 2,654, that of the grey, 2,7279.

Steatites is also sometimes a component part of granite; but Mr. Werner deduces it with great probability from the decomposition of mica. However, Hœpfner says, it is sometimes an essential component part. 4 Helvet. Mag. 267.

Porcelain earth is also sometimes found in granites, and said to arise from the decomposition of felspar; but as this earth is infusible, but common felspars on the contrary very fusible, it is not from these, but most probably from continuous felspar, that its origin must be deduced.

Shorl (I mean true prismatic shorl) is also sometimes found in granites, but only casually, that is to say, not as a constant ingredient in extended masses in the rock, except perhaps in a few countries. Werner, Classif. §. 6. Garnets have also been found in it, but very rarely. Ibid. Also shorlaceous actinolyte, and chlorite. 4 Helvet. Mag. 266. See also Renovanz, 7.

It has lately been observed, that when granites are traversed by considerable veins of quartz or felspar, rubies and other precious stones are frequently contained in those veins. 1 Chy. An. 1792. Voight, Prack. Gebrig. Kunde §. 18.

Mr. Hacquet found, that granite reduced to powder is easily melted into a whitish green homogeneous glass. Crell Beytrag. 34.

That granite may be produced, at this day, from the agglutination of its own sand, we have an evident proof in the mole constructed in the Oder in the year 1722; it is 350 feet in length, 54 in height, of that breadth at top, and 144 at bottom; the walls were made of blocks of granite, fastened with iron cramps, the chinks stopped with moss, and the space between the walls filled with granite sand; this sand, by the oozing of the water impregnated with iron, or other causes, is now at last rendered so hard and compact, as to prevent any more water from traversing it, and cannot be distinguished from natural granite. Lasius, *Hartz*, 91.

Granites seem to pass into sandstone, Leske, S. 967.

Sienite.—An aggregate of quartz, hornblende, and felspar, or of quartz, felspar, hornblende, and mica, appears to Mr. Werner to be of later formation than the mere aggregate, of which hornblende is not a constituent part; hence he distinguished it at first by the name of *grunsten*; afterwards, however, he found the name *sienite* more proper, it having been already used by Pliny to denote a similar substance; and Chevalier Napion, having discovered in Sweden a substance which corresponds with the grunsten of Cronstedt, Mr. Werner applied this term, as Cronsted had done.

Mr. Hacquet found sienite fusible into a black glass in a moderate heat. Crell Beytr. 34.

Sienite in a slaty form, has been found in the Altaischan Mountains; it consisted of sandy quartz, hornblende, and felspar. Renovanz, 5 and 8.

The sienite, Leske, S. 1063, is worthy of particular attention; its colour is greenish; and where decomposing, whitish, and yellowish grey, it presents large patches of brown mica with small grains of white quartz, and a large quantity of greenish black hornblende, with some felspar.

The quartz is generally by far in the smallest proportion.

The granites which contain hornblende are the hardest. Mem. Par. 1773, p. 824, in 8vo. They should also be the heaviest, particularly if the hornblende be in a considerable proportion.

Granatine.—Besides the aggregates already mentioned, various other triple compounds have been discovered in Switzerland, by the indefatigable industry of Mr. Saussure and Mr. Hœpfner, which may be denoted by the name of *granatines*; of these the following are the most remarkable*:

Quartz	Quartz	Quartz	Quartz	Quartz	Quartz
Felspar	Felspar	Felspar	Mica	Mica	Mica
Jade	Shorl	Garnets	Shorl	Jade	Garnet

Quartz	Quartz	Quartz	Quartz	Quartz
Shorl	Shorl	Shorl	Hornblende	Hornblende
Hornblende	Jade	Garnet	Jade	Garnet

Quartz	Quartz
Jade	Hornblende
Garnet	Hornstone†

Felspar	Felspar	Felspar	Felspar
Mica	Mica	Quartz	Quartz
Shorl	Hornblende	Serpentine‡	Steatites§.

The shorl may be either the common, or tourmaline, or shorlaceous actinolyte.

Even calcareous spar, fluor, zeolite, and baroselenite, have been found in some granites in Switzerland. 1 Chy. An 1788, 133. Haiding. 52. See also Leske's Catalogue, G. 55, and S. 528. And 2 Sauss. 407.

According to Dolomieu, several Ægyptian monuments at Rome are formed of black trap, felspar, and mica. 37 Roz. 195.

The aggregate of quartz, mica, and garnet, is called *norka*, or *murksten*, by Cronsted.

Of Binary Aggregates of the Granitic kind.—Grunsten, Granitell.—Binary aggregates of quartz, felspar, mica, shorl, hornblende, &c. are called by Mr. Hœpfner, *simple granites*. Wallerius bestowed this name on the aggregate of quartz and felspar. Mr D'Aubenton calls the aggregate of quartz and shorl, or of quartz and hornblende, *granitell*. Mr. Brisson by this term understands the aggregate of felspar and shorl. To avoid all ambiguity, I would propose to denote all these duplicates in general by the name granitell; specifying, when necessary, the peculiar constituent parts of each.

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* 1 Sauss. 107, &c. 1 Helvet. Mag. 281.

† Renovanz, p. 5.

‡ 5 Bergm. 128.

§ Renovanz, 5.

Mr. Werner, and his school, at present denote only the aggregate of hornblende and felspar, or mica, by the name of *grunsten*, as Cronsted had done before. Werner uberdie Gange, 79. It were not amiss that every other combination, not merely accidental, but of which mountains or large tracts actually consist, were also distinguished by a peculiar name.

The granitells hitherto noticed by Saussure, Hœpfner, and Haidinger, are,

Quartz	Quartz	Quartz	Quartz	Quartz	Quartz	Quartz
Felspar	Mica	Shorl	Hornblende	Jade	Garnet	Steatites

Felspar	Felspar	Felspar	Felspar	Felspar
Mica	Shorl	Hornblende	Jade	Garnet

Mica	Mica	Mica	Mica
Shorl	Hornblende	Jade	Garnet

Hornblende	Hornblende
Jade	Garnet

Jade	Indurated Steatites
Garnet	Shorl. 1 Sauss. 104.

The aggregate of *quartz* and *mica*, is by the Swedes called *stellstein*, whether compact or slaty. Mr. Werner, when it is slaty, calls it *glimmer schiefer*, that is, *slate mica*, or *shistose mica*,

mica, or *slaty mica*; when compact, it may perhaps be proper to call it *stellstein*; when slaty, *shistose mica*. When its coherence is moderate, and the mica dispersed through its substance, it has often the appearance of a sandstone, and is called by the French *micaceous grit*, or primitive micaceous sandstone.

Stellstein is found either grey, green, or red; its appearance is variable according to the proportion of its ingredients. The mica often runs in veins or stripes; it is used as a firestone.

The stone called *aventurine*, of which we have already spoken, may be considered as of this species.

The aggregate of *felspar* and *mica* is called *rapakivi*, its colour is brown, or brownish red, it moulders by exposure to the air, but that is only when the mica exceeds; when the felspar exceeds, it forms a durable stone called in Italy *granitone*. Ferber *Italy*, 118.

The aggregate of *hornblende* and *mica* is generally dark green, and hence called *grunstein*.

In fact, however, the addition of mica to any stone cannot, with propriety, entitle it to be placed in the granitic order; as mica does not form a grain, but attaches itself indifferently to many sorts of stones. Thus we have micaceous limestones, micaceous potstones, micaceous argillites.

The aggregate of *quartz* and *steatites* is called *Saxum molare* by Wallerius; its colour he tells us is grey, green, or red. Mr. Mongez tells us it is also found in Dauphiné.

Mr. D'Aubenton calls the aggregate of *quartz* and *felspar*, granatin.

In some aggregates of *quartz* and *shorl*, slender capilliform needles of red shorl traverse the quartz, and cross each other in various directions. This stone is in some estimation, and is by the Germans called *hairstone*. It is found in Siberia.

Granilite.—Granites Indeterminatus of Hœpfner.—Under this denomination, we may comprehend all granites that contain more than three constituent parts.

Of this sort many are mentioned by Hœpfner, Saussure, Haidinger, and in 2 Chym. Ann. 1785, p. 22.

Quartz
Felspar
Mica
Shorl

Quartz
Felspar
Mica
Steatites

Quartz
Mica
Shorl
Garnet

Quartz
Felspar
Mica
Garnet

Quartz
Baroselenite
Mica
Shorl

Quartz
Baroselenite
Mica
Hornblende.

The two last aggregates were found forming a whole mountain in Switzerland, by Mr. Hœpfner. 1 Chym. Ann. 1788, p. 134. The baroselenite was of a flesh red colour.

*Gneiss**.—*Roche feuilletée of Saussure, in part.*—To Mr. Werner we are indebted for a precise description of this stone. According to him gneiss, like granite, consists of quartz, felspar, and mica. Of *a thick, slaty, continuous, or fibrous texture,* and not of a granular, as when they form granite. And hence a slaty granite is not on that account to be called a gneiss, as it is still granular.

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* Werner, Kurze Classification, §. 8. Bergm. Kalendar, 1790, p. 202.

In gneiss also mica is in the smallest proportion, and felspar generally is nearly an equal in proportion with the quartz, except the gneiss approaches to granite, for in that case the felspar predominates, as does the quartz when gneiss passes into *shistose mica.* If the gneiss be split longitudinally, the mica will appear in the largest proportion, because the layers of mica are the most fissile. Voight, §. 20. But, if broken across, it will appear otherwise.

The felspar in gneiss is often decomposed and passes into clay, and the mica sometimes into steatites, particularly near veins.

Garnets are often found in gneiss, but of no value; so also is shorl, and tourmaline; and, in Switzerland, also shorlaceous actinolyte, hornblende, and talc. Per Hœpfner. 4 Helv. Mag. 268. Voight, Prack. Geb. §. 20.

The transitions of gneiss are into granites, shistose mica, and shistose hornblende.

The hardness of gneiss is as variable as that of granite; its slaty texture is often only perceptible to the eye, for it refuses to split, though it breaks more easily in that direction than in any other. 1 Sauss. 114.

The quartz grains are generally more blunt in gneiss than in granite; the felspar, often thin, and flatted in the direction of the laminæ; yet sometimes thick, and placed obliquely to their direction. The mica often runs in veins parallel to each other. Sauss. 117. The plates or laminæ are often of unequal thickness, straight, or variously bent.

Withered gneiss has sometimes the appearance of a grey slaty mortar, as in Leske, O. 68; or of a reddish and yellowish mortar intermixed with mica, as in O. 371.

Sometimes it abounds so much in hornblende, as to resemble hornblende slate, as in S. 768.

Shistose Mica.—Glimmer Schiefer of Werner. Roche feuilletée of Saussure, §. 160— This consists of quartz and mica more or less intimately mixed, and of a slaty or shistose texture, straight, or curved, it contains more mica than gneiss does; sometimes the quartz is not distinguishable. I doubt even, whether talc, rather than mica, be not often one of its constituent parts. Sometimes the quartz and mica are found stratified with each other.

It frequently contains garnets (and then, as the compact sort already mentioned, is called murksten), and according to Haidinger also shorl, actinolyte, and sappare.

Sometimes granular limestone holds the place of quartz, as in Leske, S. 1520. The specimen 1512 is of a bluish grey colour, with an uneven shistose fracture, and worthy of particular notice; it also contains granular limestone.

Its transitions are into gneiss, argillite, shistose chlorite, and porphyry.

Sometimes it is so decomposed as scarcely to be distinguished, its colours yellowish, or reddish grey, or brown, sometimes nearly black, however, it always retains its fissile texture.

Murksten is remarkably heavy. See Leske, S. 293.

When the mica is dark blue, or lead coloured, or nearly black, this stone much resembles hornblende slate, or at least an argillite mixed with hornblende; but the softness of the mica, and the specific gravity, sufficiently distinguish them. See Leske, G. 131.

*Porphyry**.—Any stone which in a *siliceous* or *argillaceous* ground, or basis, contains scattered specks, grains, or dots of felspar, visible to the naked eye, is at present denominated a *porphyry*. But with felspar it may, and generally does, contain quartz, hornblende, and mica; these inhering stones are generally of a different colour from the ground; in which, as in a cement, they are stuck and crystallized; nay, of late this name has been given to stones which do not contain felspar, at least visibly. See Leske, G. 233, 236.

I do not see any reason why calcareous or muriatic stones, containing felspar, should be excluded; hence I distinguish four sorts of porphyry, the *siliceous*, *argillaceous*, *muriatic*, and *calcareous*; most of which may be *compact*, or *shistose*, or *slaty*.

The felspar contained in porphyries is commonly distinguished by its oblong quadrilateral shape, though it is often in rounded grains. 2 Chy. Ann. 1790, p. 16. Very frequently it is disintegrated or decomposed. It is said to differ in hardness and fusibility from common felspar; those most usual in granites possessing these properties in a higher degree; it may therefore be, if *grey*, the labradore; if *brownish red*, the petrilite; if *greenish*, the felsite; porphyries containing large crystals or fragments of felspar, from 0,4 to 0,9 of an inch, are by the French called *serpentins*; their basis is supposed to be a jasper, but commonly, I believe, it will be found to be a hornstone. Brisson, p. 126. 35 Rozier, 128.

The specific gravity of porphyries is necessarily

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* Kurze Classif. §. 12.

sarily different with the nature and proportion of their bases.

Of Siliceous Porphyries. Leske, S. 1090. —Siliceous porphyries have either jasper, hornstone, pitchstone, obsidian, siliceous shistus, shistose hornstone, or felspar itself for their basis.

Jasper Porphyry.—The existence of this has lately been called in question. Mr. Werner expressly says, he never met any. 1 Bergm. Journ. 1789, 600, in a note. Mr. Faujas, from the great fusibility of the porphyries that were presumed to have jasper for their basis, thinks that it must be of a different nature. This point, however, is not yet perfectly ascertained; see Leske, G. 212, and 2 Chy. Ann. 1790, 19; nor perhaps can, in particular instances, without examining the fusibility of the specimens in question.

Hornstone Porphyry.—These are distinguished by their hardness, and a conchoidal fine splintery fracture, their slight transparency, and want of lustre; they are also not difficultly fusible; of this sort is the porphyry. 1 Sauss. §. 150, 156, and 157. And many more in Leske, G. p. 25, &c.

Sometimes the felspar is decayed, and sometimes the hornstone also, while the quartz and hornblende remain entire; this gives the whole the appearance of indurated volcanic ashes, though the quartz might prove the contrary; if the felspar alone be decayed, the hornstones will appear porous, and may be taken for a lava. See Leske, G. p. 26, &c. Its transitions are into granite and sandstone.

Pitchstone Porphyry. Leske, S. 1779.—Its colour, black, grey, green, red, or yellow, of various shades, generally many colours at once in the same specimen. Lustre, greasy 2.1. Transparency, 2.1. Fracture, imperfectly conchoidal. Hardness, 8, 9, 10. The felspar often blue. See Liebenroth Beobacht, 42. Of this see a remarkable specimen, Leske, S. 950. Its hardness, 10. Lustre, 1.

Of some the fracture is slaty, as for instance, that in Leske, S. 1779. Its colour, yellowish grey. Lustre, scarcely 1. Transparency, 1. Hardness, scarcely 9. Specific gravity, 2,452.

Obsidian Porphyry.—Black, or greyish black. Lustre glassy, 3.2. Transparency, 0, or 1. Fracture, perfectly conchoidal. Hardness, 10.

Horn Porphyry.—Porphyr Schiefer of Werner. Leske, S. 1130, 971, 973.—This has siliceous shistus, or hornslate for its basis; but, as other porphyries may have also a slaty or shistose texture, Mr. Nose justly proposes to distinguish this we now treat of by the name of horn porphyry. 2 Nose, 432. It frequently contains hornblende and quartz much more apparently than felspar.

The ground is generally bluish, or greenish, and the felspar white, and often exceeding minute; this gives the whole a bluish or greenish grey appearance, sometimes also a yellowish grey, and these last strongly resemble wacken porphyry. See Leske, S. 1015.

Lustre, 1. Transparency, 0 or 1. Fracture uneven, coarse, or fine splintery; sometimes tending to the conchoidal; frequently slaty in the gross.

Hardness, 9, 10.

It is often found decomposed, or disintegrated.

The grain of this stone is often as fine and close as that of hornstone; but then it does not give fire with that smartness, that hornstone of that fine grain does.

It passes into argillite and trap.

The basis of the horn porphyry, Leske, S. 1041, seems a middle thing, between siliceous shistus and argillite; its colour bluish grey, with some reddish and whitish specks; fracture, thin slaty; hardness 10; surface shews a whitish brown crust from decomposition.

Petunse Porphyry.—Porphyry that has felspar for its basis is called by this name.

Its colour is generally yellowish brown, or reddish brown, or brownish red, or reddish grey, or flesh coloured, or yellowish red.

Lustre, 0. Transparency, 0. or scarcely 1. Fracture unequal, or earthy, or fine splintery, or presenting small folia or lamellæ, often presents distinct concretions. Hardness, 10.

The rock, mentioned in 2 Sauss. §. 728, seems different, being much more fusible. See Leske, S. 1158.

Of Argillaceous Porphyries.—These may have indurated clay, hornblende, trap, wacken, mullen, kragg, or argillite, for their basis.

Clay Porphyry.—*Leske*, S. 1094, 1096.—Its colour is generally of some shade of grey, or greenish grey, or brown, or blackish, or reddish brown, or Isabella yellow.

Lustre, and transparency, 0; fracture, earthy; hardness, from 5 to 7. It sometimes adheres to the tongue.

Of this sort is the *metalliferous stone* of Born, or *Craustein* of the Germans, so celebrated in Hungary; its colour is some shade of green, mostly dark, even inclining to black, rarely reddish; it consists of indurated clay, in which hornblende, felspar, mica, and quartz, are found. 1 Bergm. Journ. 1789, 606. Haid. 42. See the Specimen, Leske, S. 289.

This porphyry is much subject to decay; the felspar either moulders, or loses its lustre; the hornblende also; and the whole has then been often mistaken for volcanic traass.

The reddish porphyry of the Hartz, mentioned by Lazius, whose specific gravity is so low as 2,405, is probably of this species. Also the porphyry of Pottchapel, described by Mr. Weiss, 6 Lempes Magaz. p. 52, which consists of quartz, felspar, and mica, held together by a grey clay, and there called a white sandstone.

The Isabella yellow clay porphyry, Leske, S. 1221, is remarkable, it has the earthy aspect of a marl. Its lustre, and transparency, 0; fracture, earthy; hardness, 9; specific gravity, 2563. At 148° melts into a greyish glazed porcelain. The felspar in this stone is ochre yellow, and easily distinguished while the stone is undecayed, but it is very subject to moulder.

Hornblende Porphyry.—Ophites of Brisson.—Masses of sienite, in which the hornblende abounds, may deserve this name. The colour of the basis is black, or greyish black, or dark green, or yellowish green; the fracture striated, or foliated. Specific gravity, when the proportion of hornblende is considerable, 2,972.

Trap Porphyry.—Its colour is greyish, or bluish black, or blackish, or reddish brown, or greenish grey; lustre, and transparency, 0; fracture, earthy, or fine splintery; hardness, from 7 to 9; its specific gravity exceeds 2,7.

Of this sort is that of Montelimar, described by Faujas, on trap, p. 130. Sometimes it abounds so much in quartz and felspar as to have its hardness 10. See Leske, S. 895.

Wacken Porphyry.—See Leske, S. 894.—Greenish, blackish, reddish, or yellowish grey, or greyish black, or liver brown.

Lustre, and transparency, 0. Hardness, from 6 to 9. Fracture, even, earthy, seldom uneven. Feels somewhat sandy.

Mullen Porphyry.—Bluish grey, light or dark. Lustre, and transparency, 0. Fracture uneven, and fine splintery. Hardness, from 7 to 9. Specific gravity, from 2,6 to 2,728. Of this sort are the porphyries mentioned, 2 Chy. An. 1790, 18.

Kragg Porphyry.—See Leske, S. 1078, 1079, 893, and 941.—Greyish red, or dark purplish red. Lustre, and transparency, 0. Exceedingly porous.

Fracture, uneven and earthy. Hardness, from 5 to 7. Feels rough and harsh; gives a yellowish grey, or reddish streak.

It often verges to sandstone.

Argillitic Porphyry.—This is distinguishable

able from the foregoing not merely by its slaty fracture, but also generally by its lustre; and often by its slight transparency. It is found in the Bobrousky Mountains. Renovanz, 5.

Novaculite Porphyry.—Greenish grey, or greyish yellow. Lustre, 0. Transparency, 1. 1,5. Fracture, fine splintery, earthy, or slightly conchoidal; but, in the gross, often slaty. Hardness, from 7 to 8, rarely 9.

Feels somewhat greasy.

Muriatic Porphyries.—These have either potstone or serpentine, for their basis.

Potstone Porphyry.—Greenish, reddish, or yellowish grey, or specked with red, or leek green.

Lustre, 2. 1. Transparency, 1. 0. Fracture undulatingly foliated; the folia very thin; its hardness, from 4 to 6. Specific gravity exceeds 2,7.

Serpentine Porphyry.—Dark or olive green, or greenish grey, or brownish red, or greyish blue, or yellowish, and yellowish green.

Lustre, 0. Transparency, 1,0. Fracture, fine splintery, often passing to the uneven. Hardness from 6 to 7. Specific gravity, not exceeding 2,7. Feels rather soft. Found near Florence.

Granitic Porphyry.—When porphyry is overloaded with felspar, it is often difficult to say whether it be a granite, or a porphyry which hath a granitell for its basis. Thus the porphyry, in 1 Sauss. §. 154, may be considered either as a granite, since it consists of quartz, shorl, and felspar, or as a porphyry, as the quartz and shorl crystals are very minute, and the felspar, on the contrary, is easily and fully distinguishable. See also Leske, G. 45, and 214; and 35 Roz. 126.

To this sort we may also annex porphyries of which the ground makes by far the smallest part, as that described by Herman, 2 Chy. An. 1790, 21, and which he calls a *porphyrite*. It consists of small sparks of felspar, grains of quartz, splinters of hornblende, and fragments of shorl cemented together by a scarcely discernible jaspidean cement. Its lustre, 0. Fracture fine splintery. Hardness, 9. Transparency, 0. Colour greyish, black, or red, or white. Also Leske, S. 1090.

Sandstone Porphyry.—The yellowish grey argillaceous sandstone, which contains large grains of felspar and quartz. Lasius, p. 158, is of this species. Specific gravity, 2,564. It readily moulders by exposure to the air.

Of Porphyries with a derivative basis. Leske, S, 459.—Derivative stones (of which more in the sequel) are also frequently the ground of porphyries; of this sort is the *earthy hornstone porphyry,* Leske, S. 459. Colour, dark reddish brown. Lustre, 0. Transparency, scarcely 1. Fracture, fine splintery. Fragments, nearly 3. Hardness, 9. Specific gravity, 2,617. The felspar is scattered small and white.

Amygdaloid.—Mandelstein of Werner.—By this name I understand any stone, of the argillaceous class, which contains as in a ground, or basis, rounded, or eliptic masses of calcedony, agate, zeolite, calcareous spar, lithomarga, steatites, green earth, often also garnets, hornblendes, and opal; with some or other of these, though very rarely, felspar has also been found, Leske, G. 314.

This basis is generally indurated clay, trap, wacken, mullen, kragg. Sometimes it is so decomposed as to resemble mortar, as in Leske, O. 634, 1016; the specimen, S. 236, is a kragg containing olivin.

Its colour is grey, or blackish, or greenish, or reddish grey, or brown, or brownish red, reddish brown, or pale, or mountain green. Lustre, 0. Transparency, 0.

Fracture, uneven, or splintery, or conchoidal; often earthy.

Some give a white, some a reddish streak.

Hardness, from 6 to 9. Specific gravity, variable, not only from the difference of its contents, and of its basis, but also from the state of integrity, or of disintegration, in which it may exist. Some I have found at 2,354, as that in Leske, G. 300; some at 2,443, as that in Leske, G. 296. The *toadstone* of Derbyshire comes under this denomination.

Lasius remarks of that found in the Hartz, that the calcareous concretions contained in it, often wither by exposure to the air; and then the basis acquires the fallacious appearance of a lava. The deeper the stone lies in the earth, the larger the cavities it contains. Lasius, *Hartz*, 259. The formation of the various concretions found in it is most ingeniously explained by him. Its transitions are into trap.

Pudding Stone.—Under this name Mr. Werner comprehends a collection of small rounded pebbles, partly of quartz, partly siliceous shistus, or flints bedded in an argillaceous ground, or in jasper, or quartz, or even in sandstone. According to Haidinger, pudding stones consist of flints of various colours, cemented by a substance of the same nature ; and, according to Saussure, this name is applied to a collection of small flints compacted together. As this name was invented by English lapidaries, we must apply it as they do; and they certainly acknowledge no other ground or cement than a siliceous, or ferruginous as hard as flint; hence we may define it a collection of rounded pebbles, of the siliceous genus, cemented by a substance of the same genus, or a ferruginous compound of equal hardness. The colour of the cement is whitish, or yellowish grey, or yellowish, or reddish brown, or red, or brownish red ; its fracture, generally conchoidal.

The pebbles are of various sizes, from the bigness of rape seed to that of an egg ; they are always rounded, or elliptical, and frequently compressed : the finer sorts take a fine polish, the coarser are used for mill-stones.

The nature of the ground, and its superior hardness, sufficiently distinguish this aggregate from amygdaloids ; besides its pebbles are always siliceous, whereas spar, &c. is found in amygdaloids.

Sandstones.—These consist of grains, not exceeding one-third of an inch, of quartz, flint, hornstone, siliceous shistus, felspar, or sometimes mica imbedded in a calcareous, argillaceous, siliceous, or ferruginous cement ; the ferruginous is indeed very frequently intermixed also with the foregoing.

Sandstones are either fine grained, or coarse grained, and of various degrees of coherence and hardness, most of them feel rough and sandy; the least coherent break into sand.

Their fracture is generally earthy.

Almost all sandstones absorb water in various proportions, from $\frac{1}{10}$ to $\frac{1}{227}$ of their weight; as appears by Mr. Brisson's experiments; those used for filtering absorb $\frac{1}{10}$ of their weight.

Calcareous Sandstones——Are those which have a calcareous earth for their basis or cement, and this earth may be pure, or nearly so, or marly, or marlitic; both may be coarse grained, or fine grained, compact or slaty.

Their colour is generally white or grey, or yellowish white, or yellowish grey, or brown, or reddish brown. Their surface rough; fracture earthy or slaty. Hardness, from 6 to 7. They are frequently burned for lime, and when free from argill they harden when exposed to the air. They are often sprinkled over with mica.

These sandstones have been found crystallized in rhomboidal tables superimposed one upon the other, and thus forming a sort of pyramid, or in rounded masses. The sandstone of Fontainbleau is a remarkable specimen of this kind, its colour is grey for the most part, though some yellowish and reddish are found from a small contamination of iron. Hardness, 9. Specific gravity before penetration with water, is 2,5739; and after penetration, 2,6111. It contains by the experiments of Mr. Lasone 62,5 per cent. silex, and 37,5 mild calx; he remarked that it gave out very little air by heat. The cos, quadrum, of Wallerius, seems to be of this sort.

Another crystallized stone of this sort was found in the territory of Juliers, its colour reddish grey, but invested with a red ochry dust. Its fracture small-grained foliated. Specific gravity, 2,555. Its form quadrangular and tabular. By the analysis of Mr. Westrumb, it contains 70 per cent. of silex, 15 of mere calx, 4 of fixed air, and 10 of calx of iron. 2 Chy. Ann. 1789, p. 31. Here it is remarkable, that the calx contained nearly more by the one-half fixed air than it usually does.

Baron Born mentions a flesh-coloured spar visibly mixed with quartz, whose fracture presents a surface concentrically striated, and whose density is considerable; it effervesces with acids, and gives fire with steel. It contains manganese, to which both its colour and density are owing. 31 Roz. 22.

Calcareous marls that contain less than 33 per cent. of mild calx, the remainder being either wholly siliceous, or at least containing so little argill as not to form a brick when burned, may be annexed to this class. Of this sort is the light grey marl of Dr. Withering, Phil. Trans. 1773, 161, No. 6. It contains but 0,26 of mild calx, withers by exposure to the air, and will not burn to brick.

Those of a slaty texture generally have a marl or marlite for their basis, their colour most frequently is Isabella yellow, or brown.

Argillaceous Sandstones.—These have argill or clay for their ground or basis, none effervesce with acids, some are fusible and some not. Their hardness is from 6 to 8, rarely 9. They are often shot through with mica. They are compact or slaty, coarse or fine grained.

Of the coarser sort are formed various millstones consisting of minute fragments of quartz, felspar, and flints, in an argillaceous cement. These may also be considered as porphyries, filtering stones, and the coarser whetstones.

They often contain impressions of marine shells; sometimes appear cellular, the quartzy particles having fallen out; but sometimes they contain nests of porcelain clay. Baron Born mentions a grit of this kind found in Bohemia, whose grains were oblong, and so interwoven, as to be in some degree flexible and elastic. 1 Raab. 408.

The greenish grey often resemble wacken. See Leske, S. 62.

The slaty sandstones of this sort are either grey, or yellowish grey, or brown, or brownish red. Of this kind is the red sandstone, called *rothe todt liegendes*, or the *red deadlier*, from its being found either under strata of coal, and generally denoting that under it no more coal is to be expected. It is commonly micaceous, and often contains lumps of porphyry, or granite imbedded in it.

Siliceous Sandstones.—These in a siliceous ground may comprehend grit or sands of a calcareous nature, or one species of the siliceous genus may serve as a cement for grains of a different species of the same genus. Or even grains of the same species slightly compacted together and easily breaking into sand, may be thus denominated. See Leske, S. 1773. Its lustre and transparency, variable.

Salindre is a sandstone of this kind, consisting of calcareous grains inserted in a siliceous cement, of which Abbé Sauvage treats in Mem. Par. 1746.

Mr. Rosler mentions a sandstone found in Bohemia, consisting of grains of quartz in a flinty cement, 1 Bergb. 357; and various others occur in the Cabinet of Leske, 788, &c. and 1 Raab. 401, &c.

These sandstones frequently pass into granite. See Leske, S. 1079, 1080.

Siliceous sandstones, when the siliceous matter is much debased, as in some earthy quartz or hornstone, has often the appearance of an argillaceous sandstone, but its hardness often serves to prevent any mistake. Of this we have an instance in Leske, S. 1275, whose colour is yellowish, and reddish grey, and looks like mortar; but its hardness is 10. Lustre, 0.

Ferruginous Sandstones.—Their colour is generally of a deep shade of red, yellow, or brown, or greyish black; sometimes they exhibit a kind of network.

The agglutinating power of moist semi-oxygenated calces of iron has been well ascertained. Mr. Edward King describes a stony concretion, found enveloping a mass of iron long buried in the sea. Phil. Trans. 1779, p. 35. And Mr. Gad informs us of another, discovered by Mr. Rinman. Mem. Stock. 1770. He also shews by his own experiments, that calces of iron much oxygenated do not possess this power, which is farther confirmed by the experiments of Dr. Higgins, in his valuable Treatise on Cements. Hence it appears that stones, whose cement is ferruginous, are less magnetic after torrefaction than before, Brugman, 93; as they acquire, instead of losing air; and as most species of stone contain some proportion of iron, intimately diffused through their whole mass, it is probable, 1st, that their cohesion in many instances proceeds from it. 2nd, That their iron, at the time of the formation of stones, was in a semi-metallic slate. 3d, That their decomposition, by their exposure to the air, proceeds from its oxygenation.

Of this kind is the ferruginous sandstone, mentioned by Mr. Stutz, 2 Bergbau. 398, it afforded 19 per cent. of iron.

The ferruginous part is in general somewhat mixed with argill.

Rubble Stone.—Grauwacke of Werner. Gres Gris of the French.—This is a particular kind of sandstone, containing not only grains of quartz, siliceous shistus, or hornstone, but also scraps of bluish argillite in a clayey cement, and of this there is often no more than is barely sufficient to hold the grains together, sometimes with, and sometimes without mica; commonly compact, sometimes slaty in the gross.

Its colour is yellowish, or bluish grey, or dark reddish brown mixed with grey.

Fracture, in the small, fine splintery or earthy. Hardness, from 7 to 9, rarely 10. Specific gravity, from 2,64 to 2,685, but when withered, only 2,60*. See Leske, O. 1278, and S. 474, 607.

Breccias.—These are either simple or compound; simple breccias consist of angular fragments of the same genus, agglutinated or compacted together; or of stones of one species imbedded in a cement of the same genus, whether the species be different or not.

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* Lasius mentions some whose specific gravity is 3,457. But the 3 seems an error of the press. Hartz, 143.

Thus a *calcareous breccia* consists of fragments of marbles, of different colours, held together by a calcareous cement. This is often simply called a *breccia*, as the term was originally applied only to aggregates of this sort.

A *jasper breccia*, consists of jaspers of different colours, stuck in a jasper ground, &c.

Some apply the term breccia to aggregates which contain rounded fragments, as Gerhard, Cronsted, and Haidinger, who comprehend pudding stones under this appellation.

Compound breccias consist of fragments of stones, or aggregates of various species, or genera, stuck in a cement of a different genus; thus trap in which fragments of granite are stuck,. or a trap in which granite, argillaceous shistus, and limestone fragments, are found, form breccias. Faujas *Trap*, p. 115. So also the *sandstone breccia*, mentioned, 2 Crell. Beytr. 63, which contains argillite, quartz, and mica, in a cement of sandstone. Similar to this is the *nagel fluhe* of the Swiss, formed of a compacted sand, in which rounded masses of quartz, or flint with black, green, reddish brown, or grey limestone, and black argillite are firmly imbedded. Ferb. 3 Briefe, Miner. Inhalt. p. 5.

Beside those aggregates which have been generally noticed, a few others are mentioned by some systematic authors of note, which deserve particular attention, as they are frequently mentioned without any explanation.

1st, *Anomalous* or *compound grits*. Of this sort is that of Julian near Geneva. 41 Roz. 99; which is composed of quartz, felspar, mica, steatites, and ferruginous calcareous marls; while moist, it is soft, but when dry is sufficiently solid. When heated it hardens, by reason of the clay and steatites it contains. Houses are built of it.

2nd, *Horn rock, kiesel fels,* or *hornfels* of Haidinger, *Saxum siliceum* of Brunich, has for its ground a hornstone basis, in which quartz, or indurated clay, or limestone, or garnets, are found either crystallized or in veins. Its fracture is compact, mostly splintery.

3d, *Serpentine rock, serpentine fels,* of Haidinger; it is formed of serpentine, in which quartz, mica, limestone, or garnets singly, or collectively, are found.

4th, *Topaz rock* of Werner; this presents a compound of topaz, quartz, shorl, and lithomarga, confusedly compacted together. It has hitherto been found in Saxony only.

5th, *Garnet rock* of Kärsten, found by him near Winneburgh; it consists of amorphous garnet, in which trap, quartz, calcareous spar, and a very small quantity of blackish brown mica are found.

6th, *Steatitic rock, schneidestein* of Haidinger, *telgsten* of Cronsted; it consists of indurated steatites mixed with mica, or talc, or mica and felspar (and then forms muriatic porphyry) or shorl, or tourmaline.

7th, *Variolites.* The French naturalists denote by this name stones that have rounded protuberances, of a different nature from the common mass of the stone, from their resemblance to *variolæ.* However, it is applied to those also whose protuberances have been worn off, and particularly to rounded stones, of this kind, found in the beds of rivers.

Variolites of *durance* consist of a basis, of a black or dark green colour, called by the French *shorl en masse*, probably hornblende, containing according to Brisson, grey felspar. Its hardness, 9 or 10. Its specific gravity, from 2,933 to 2,988. Some native silver has been found in it. It is evidently a porphyry. Brisson calls it *serpentine* of *Dauphiné*.

Variolites of *Drac* have trap for their basis, or kragg, or mullen, and contain rounded masses of limestone, or steatites, or of both.

Still many aggregates are daily met, which cannot be arranged under any general denomination now in use. Hence I would propose to call them, if any of their constituent parts can be considered as a basis or cement, *porphyroids*; if none can be considered as a basis, *granitoids*.

CHAP. XII.

OF MIXED EARTHS, AND DERIVATIVE STONES.

WITH SUPPLEMENTAL OBSERVATIONS.

EARTHS, resulting from the mere re-union of different earths, or sands, are called *mixed*, because the ingredients united are, at least for the most part, visibly distinct, and may in great measure be mechanically separated.

Stones, resulting from the coalition of stones of different species, are called *derivatives*; they differ from *aggregates* in this, that the associated ingredients are not visibly distinct, or, at least, require microscopes to render them so. The coalescing *stones* may differ either by their ingredients, when both are composed of many, or by the proportion of some ingredient or ingredients common to both species.

If the coalescing species differ by one or more ingredients, the coalition is formed by the addition of these, or some of them, to the species that had them not, or by their subtraction from the species that had them.

So also, if the coalescing species differ in the proportion of their ingredients, the coalition is formed by augmenting that proportion in the one, and lessening it in the other.

In either case the resulting derivative stone is denominated from the species that still predominates; if it participates equally of both, it may be denominated from either.

Though this term be originally and most properly applied to stones that are intermediate between, and form the transition or gradation of one species to another, yet we may also apply it to stones which receive a superabundance of one of the simple earths, or calx of iron; or even of another compound stone, without any connection of vicinity with stones of another species which contain it in a larger proportion.

The simple earths that most generally coalesce with other stones, are silex and argill, to which we may add calx of iron. Calcareous earth and magnesia coalesce more rarely; but mica or talc, very often.

Derivative stones are exceeding common, and if their origin be not attended to, may exceedingly perplex young mineralogists. They are known and distinguished by their mixed characters, participating of those species from whose union they result. Most of the *disjunctive* characters that occur in the description of the original species proceed from unnoticed coalitions. But if a character be perceived that is not found in either of the supposed originals, the stone cannot be deemed a *derivative.*

Of mixed Earths.—The only mixed earths, to which peculiar names have been assigned, are *loam* and *mould.*

Loam, according to Mr. Woodward, consists of clay mixed with fine sand, that is, in other words, of clay with a superabundance of sand*; and in effect, Mr. Bergman, having analyzed some found in the neighbourhood of London, and considered as very excellent, found it to consist of 87 per cent. of a reddish grey sand, as fine as meal, and 13 of argill. Now if we suppose clay to consist, as it most frequently does, of 30 per cent. of argill, and 70 of fine sand, we shall find that loam of the best kind contains an excess of sand amounting to 17 per cent.; if the excess of sand be greater it will form what is called a *sandy loam*; if smaller, *clayey loam.*

Mr. Bergman found nothing calcareous in the loam; when it contains any, it so far inclines to the nature of marl, and this *marlaceous loam* may be either *sandy* or *clayey,* according as the proportion above indicated is exceeded on either side; of sandy loam, see a specimen in Leske, S. 1061. But loams most frequently contain also a proportion of calx of iron, and this calx is more or less oxygenated, a circumstance which produces a considerable variety in the colours, and probably also in the vegetative powers of this earth; if its proportion be considerable, namely, 4 or 5 per cent. they often contain also some proportion of vitriolic acid; the colour of loam frequently proceeds from that of the calces of iron contained in it, but more frequently from its sandy part.

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* Being derived from the German word *Leime*; it signified in ancient times a viscid earth. See Johnson's Dictionary.

Gravel, is a coarser sort of sand, either of a calcareous or siliceous nature, is often mixed with loams, and also pebbles, from whence new distinctions arise of importance to agriculture.

Moulds are loams mixed with animal and vegetable remains, particularly from putrefaction; generally of a black, brown, yellowish, or greyish brown colour; the proportion of these is highly interesting to agriculture; it can be pretty nearly determined by comparing their weight when dried at 140° of Fahr. with that which they lose by being heated to redness in an open fire, continued as long as any coaly substance remains in them; yet not exactly, without some nicer operations, as the animal earths will still remain undetermined, and also the vegetable ashes.

Of the Calcareous Genus.—Limestones are frequently intimately mixed not only with siliceous particles, and calces of iron, as we have already seen; but also with argillite in various marbles, see Leske, G. 328. When mixed with siliceous particles in considerable proportion,

they

they effervesce with acids, but slightly, and slowly, and their fracture tends to the conchoidal, but often also to the earthy; of this we have a remarkable instance in Leske, S. 229. Its lustre, 0. Hardness, scarcely 9. Fragments, 3; which indicates the siliceous ingredient. Its specific gravity only 2,254, which shews it to be of the nature of sandstone. Heated to 141°, it did not form a lime, nor did it melt. When the limestone is of the granular kind it has more lustre and is much heavier, see Leske, S. 1098. But when the particles of silex are in a smaller proportion, or not purely siliceous, the limestone presents a different appearance; thus the limestone, Leske, S. 1769, seems as if passing into hornstone, and is of a yellowish grey colour. Lustre, 0. Transparency, 1. Fracture, fine splintery. Fragments, 1. Hardness, 9. Specific gravity, 2,640. It effervesces briskly with acids, but melts into a greenish grey compact enamel.

Effervescence with acids is not therefore a sufficient proof that a stone will burn to lime; thus the dark bluish grey stone, Leske, O. 1229, whose lustre is 0; transparency, 0; fracture, uneven and splintery; fragments, 2; specific gravity, 2,740; hardness, 9, and which contains the impressions of various shells, and effervesces very briskly with acids, yet melts into a black compact glass. It has an earthy smell when breathed on.

Calces of Iron in a particular state, not as yet perfectly known (perhaps highly oxygenated, or combined with argill), not only communicate a yellowish or reddish colour to limestones, but seem to corrode them; of this we have one instance in the specimen, Leske, S. 1324.

1324. Its colour is reddish Isabella yellow; lustre, 0; transparency, 0; fracture, earthy; hardness, 7; specific gravity, 2,601; gives a white streak, at 141°, it hardens into a purplish red porcel in mass, and where in contact with the crucible becomes greenish. The porcelain gives fire with steel. As the stone is so light, notwithstanding the quantity of iron it contains, it is plain it must be internally corroded. See also Leske, S. 1325.

Spars, even slightly contaminated with metallic substances, are much altered in their appearance, and acquire a more granular texture; thus the spar, Leske, O. 1425, from a slight contamination of lead and pyrites, acquires an earthy uneven fracture; its colour is greyish white; its lustre, 0; its transparency, where thin, 2; specific gravity, 2,822; hardness, 9; effervesces with acids.

Marls also are much disguised by iron; the specimen, Leske, S. 453, is dark reddish brown, and reddish black; lustre, 0; transparency, 0; fracture partly even, partly splintery; fragments, 0 or 1; hardness, from 7 to 8; specific gravity, 3,398; gives a red streak; effervesces with acids.

Gypsum is frequently penetrated with marl, calcareous spar, swinestone, sandstone, and perhaps with strounthian, &c. these mixtures cause a change both in its hardness and specific gravity; its colour is then either blackish grey, or a mixture of whitish and blackish grey in layers or spots and veins; lustre, either 0 or 1; from interspersed shining particles; see the specimens in Leske, O. 1589, and S. 510; and this compound is itself often mixed with foliated

gypsum,

gypsum, which may easily be taken for mica, as in the specimen, S. 621.

All the varieties of gypsum are often met in veins in indurated clay. See Leske, S. 250, &c.

Sometimes this impure gypsum assumes a slaty form; and this often contains an excess of vitriolic acid, as the specimen Leske, S. 259, which is internally black, and externally dark bluish grey; its hardness, 7; specific gravity, 2,473; heated to redness it becomes reddish white.

The specimen, O. 1552, is very remarkable; its colour, pure white; lustre, 2.3; transparency, 2; fracture, partly granular, partly foliated; hardness, 8; specific gravity, 2,725. It sems a mixture of granular limestone and foliated gypsum.

Muriatic Genus.—Potstone is often intermixed with quartz, or some other stone of the silicoous genus; of this sort is the specimen, Leske, S. 148, and often with quartz and mica, as in O. 195. Colour of the first, light bluish grey, mixed with yellow; lustre, 2; transparency, 2.1; fracture, coarse splintery, somewhat slaty; fragments, 3; hardness, 9; specific gravity, 2,748. Perhaps also this stone is rather an indurated steatites, penetrated with siliceous matter, heated to redness it becomes brownish white, inclining to red. The colour of the second is greenish grey, enlivened by a quantity of talc or mica.

Siliciferous Potstone.—The specimen, Leske, O. 1158, is bluish black, mixed with white; its lustre, 2; transparency, 0; its fracture, uneven, partly splintery, partly imperfectly curved slaty; hardness, 9; specific gravity, 2,759. The quartz in many parts visible in the veins. It is much more imperfectly slaty than argillites are; its grain and lustre approaching more to those of plumbago.

In Leske, S. 342, a greyish green stone occurs, covered with a whitish earth, that seems formed of *steatites,* intimately penetrated with *argill* and some *talc*; its lustre and transparency, 0; hardness, 6; specific gravity, inconsiderable; does not feel greasy; its fracture, fine splintery, and imperfectly slaty; heated to redness it hardened to 9, and discovered some glimmering particles; it does not effervesce with acids.

Steatites is much disguised; when penetrated by *calces of iron* it generally assumes a bluish colour, increases in weight, but is never so hard as argillaceous stones become by a similar mixture. See the specimen in Leske, S. 882, whose hardness is 6, and gives a whitish streak.

Calciferous asbestinite, Leske, O. 626.—Its colour is partly greyish, partly greenish white, sometimes mixed with shades of pale red; its lustre, 2.3; transparency, 2, in thin pieces; form amorphous; fracture, partly granularly foliated, partly radiated; hardness, 5.6; brittle; specific gravity, 2,863; effervesces partially with acids, melts at 146° into a yellowish green glass. Kärsten and Leske term it a zeolite; but its specific gravity and vitrescence forbid this denomination.

Serpentine is sometimes intimately intermixed with *hornblende,* and thus becomes almost black, increases in specific gravity, and discovers somewhat

what of a foliated or striated fracture. See the specimen, Leske, O. 1041.

Serpentine is also sometimes penetrated with trap, and in that case also its colour is black, and its fracture splintery. Of this sort is the specimen, Leske, S. 864. It is full of separate concretions, lighter than genuine trap, and less fusible.

In the Argillaceous Genus.—*Trap* is frequently blended, or intimately mixed with hornblende slate, wacken, mullen, or kragg, singly, or with two or more of them in various proportions, and hence the variety of its colour and specific gravity often arises.

The greener sorts, if they have more lustre than ordinary, and if their density exceeds 2,8, may be supposed to contain a large proportion of hornblende slate; but, if destitute of lustre, and if their density be below 2,78, and easily fusible, they probably contain a proportion of wacken; if more difficultly fusible, most probably serpentine.

The *light grey* traps, when their density is under 2,78, may be suspected to contain mullen.

The *reddish brown* most probably are mixed with kragg.

Mr. Kärsten supposes trap to be formed of an intimate mixture of hornblende, quartz, and felspar; and in effect if we suppose it formed 0,60 hornblende, 0,30 quartz, and 0,10 felspar, we shall have a stone whose specific gravity shall be 2,829; but this stone will not contain the proportion of iron that Bergman found in trap, and which, by the various analyses mentioned by Mr. Faujas in his Treatise on Traps, appears to be never less than 20 per cent.; for, hornblendé, by my analysis, contains 23 per cent. of iron, and by Mr. Weigleb's still less; consequently a stone containing 60 parts of it can contain but 13,8 of iron at most, nor can we obtain by this means a stone whose specific gravity amounts to 2,98, as that of trap often does.

Siliciferous Trap, *Leske*, *G.* 173.—This arises from an intimate mixture of trap with some stone of the siliceous genus. The specimen in Leske, S. 1230, presents the following characters:

Colour, blackish grey, or dark iron grey, with numerous rounded white specks, as small as the point of a pin; it is moreover full of rifts, and these exhibit a bluish, or reddish ferruginous illinition.

Lustre, 1.0. Transparency, 0,5.1.

Fracture, uneven, fine splintery. Fragments, 3.

Hardness, 10. Specific gravity, 2,668.

At 140°, it melts into a whitish grey, exceeding porous, spongy, tumified, porcelain mass glazed on the surface.

Mr. Kärsten thinks it a compound of trap and lydian, but the effect produced by heat does not countenance this supposition. I call it siliciferous, merely from its external characters; it has a closer and more flinty grain than trap.

It seems to be the *hornatiger trap* of Lasius, No. 27, which is speckled as this is, and whose specific gravity is also 2,680.

Of this mixture there are various gradations. The changes it undergoes from heat clearly discriminate it from hornstone, into which, however, I believe it often passes on the one hand, as it may to common trap on the other.

Another specimen of this sort occurs in Leske, S. 1232, in which the grey and black parts are more distinctly separated from each other, it is covered with a yellowish grey rind.

The lustre of the grey part is 1, from a few interspersed glimmering particles; of the black part, 0. Fracture of the grey, uneven, and partly fine splintery; of the black imperfectly conchoidal.

Hardness of the black, 8, of the grey 9 to 10. Specific gravity, 2,705.

At 130°, this stone melted into a black compact, and partly into a porous dark greenish yellow enamel.

Trap intimately mixed with Kragg.—Of this, Leske, S. 1223 seems a specimen.

Colour, greyish black, yet with a shade of red, and externally it is invested with a whitish grey rind from decomposition.

Lustre, 0. Transparency, 0.

Fracture, uneven, and fine splintery. Fragments from 2 to 3.

Hardness, from 8 to 9 Specific gravity, 2,728.

At 148°, it melted into a somewhat porous, liver brown porcelain mass, whose lustre approached to that of an enamel.

Hence it is plainly a distinct fossil from common trap.

Trap intimately mixed with Hornblende.—Of this sort is the specimen, Leske, G. 264.

Colour, bluish or greenish black. Lustre, 1, from some glimmering particles. Transparency, 0. Fracture, fine splintery. Fragments, 3.

Hardness, 9. Specific gravity, 3,472.

It contains some grains of magnetic ironstone, which raises its specific gravity so high.

Lasius, *Hartz,* mentions a trap of a dusky green colour, which does not give fire with steel; is sprinkled over with black spots, offers an uneven fracture, and whose specific gravity is 2,850; most probably mixed with hornblende.

Trap intimately mixed with Serpentine.—Lommer is said to have found a stone of this sort; but I can find no description of it.

Siliciferous Argillite. Leske, G. 153.—This with the appearance of an argillite seems at the same time intimately penetrated with some stone of the siliceous genus; generally siliceous shistus, or sand, or jasper, or basanite, or quartz.

Colour, dark, blackish, or bluish grey, or grey with black or deep blue blotches, or reddish, or yellowish grey, more rarely greenish grey.

Lustre, 1.2. Transparency, 1.

Fracture, in the gross, slaty; but of single laminæ, often splintery, or conchoidal.

Hardness, from 8 to 9. Specific gravity, from 2,615 to 2,67.

Sometimes the quartz seems the most considerable part of the compound, but still preserves the slaty appearance; and the seams are of a darker colour, as in the specimen, Leske, S. 747.

Sometimes the siliciferous argillite is also ferruginous, which renders it much heavier, as the specimen, Leske, O. 774, which is also micaceous. Its colour is dark bluish grey, with veins of red, and some of white quartz; its lustre 1, from dispersed mica; hardness, 9; it is but imperfectly slaty.

Trapiferous Argillite. Leske, G. 149.—This is mentioned, but insufficiently described, by Lasius. Hartz, 104.

Its colour, bluish black

It splits difficultly.

Hardness, 8. Specific gravity, 2772.

Talcose Argillite.—Colour, whitish, or bluish, or greenish grey, often invested with foliated steatites.

It is found in large masses.

Lustre, 3. Transparency, 0.

Fracture, slaty, mostly thin, and very thin, curved slaty. Hardness, from 4 to 6. Specific gravity, 2,717.

It often involves quartz between its laminæ.

This is the stone mentioned in Leske, G. 133, and which Kärsten styles a middle thing, between mica and argillite; it is, indeed, hard to distinguish whether the minute shining scales it presents are mica or talc; but as this stone is found in great plenty at Holyhead, and there often invested with a crust of foliated steatites, and sometimes includes masses of pure talc and amianthus, I presume these foliaceous shining scales are also of the muriatic genus.

Calciferous Argillite.—The specimen, Leske, S. 1104, effervesces smartly with acids. Its colour, greyish and reddish purple; lustre, 1,5, scarcely silky, with minute glittering particles; transparency, 0; fracture, slaty, but does not split easily into very thin lamellæ; hardness, 7; specific gravity, 2,721; gives a purplish grey streak.

Hornblende Slate, penetrated with Talc or Mica.—Colour, greenish grey.

Lustre, 2. Transparency, 0.

Fracture, slaty, and thin slaty, the laminæ not easily separable. Fragments, 3.

Hardness, from 8 to 9. Specific gravity of the specimen I tried, which had exceeding thin layers of quartz between its laminæ, 2,815.

Feels very rough.

It is found in great plenty at Holyhead, and has for the most part thick layers of quartz intercepted between its laminæ.

Hornblende penetrated with Garnets.—Its colour is dark greenish red, or reddish dark green, according to the proportion of garnet. Its lustre is only derived from the garnet mixture; fracture, earthy, or fine splintery; hardness, 9; specific gravity exceeds 3; if mica be superadded, it is generally shistose.

Hornblende Slate penetrated with an excess of Quartz.—Of this we have a remarkable specimen, Leske, S. 1087; its colour is ochre yellow, with black shining streaks of hornblende; fracture shistose; it feels sandy; hardness, 10. The yellow colour seems to proceed from a ferruginous quartz. It has some resemblance to gneiss.

Mullen penetrated with Asbestinite.—Of this we have a specimen, Leske, S. 100.

Its colour is reddish grey when fresh broken, arising from a mixture of reddish brown and ash blue particles; of the reddish, some possess little, some no lustre; but the ash grey have all some, and even a considerable lustre. Its surface appears decomposed, and of a ruby brown; fracture, uneven and earthy; hardness, from 6 to 7; specific gravity, 2,586, the aggregate being coarsely compacted. The most glossy of the reddish particles, resemble the faces of felspar.

Trap passing into Granite.—We often meet stones which have so great a resemblance both to trap and granite, that it is hard to know to which of them they should be referred; of this sort are, 1. The stone in Leske, S. 988; its colour greyish blue, or black, with a number of distinct white particles, and also of oblong shining black particles, which seem to be hornblende; and others black and opaque which may be trap.

Its hardness, is 9; specific gravity, 2,916. The white parts do not seem to me to be quartz; the specific gravity of the stone is incompatible with so large a quantity of this.

Ferruginous Argillites.—Of these some are so penetrated with calces of iron, as scarcely to indicate a slaty texture; of this sort is the specimen, Leske, O. 948.

Its colour is bluish brown; externally, it has some lustre; internally, none.

It has somewhat of a striated as well as of a slaty appearance.

Its hardness, 7. Specific gravity, 3,188. It rapidly imbibes water.

Argillites with an excess of Argill.—These are generally softer and lighter than genuine argillites.

Of this sort is the specimen, Leske, O. 949.

Its colour is greyish blue, its lustre and transparency, 0. Its fracture, fine splintery and somewhat striated, but in the gross slaty. Its hardness, 6. Specific gravity, 2,668.

The lighter and softer kinds, mentioned by Lasius, are probably of this sort.

Of the Siliceous Genus. Iron shot Quartz.—Quartz is singularly disguised by iron, scarcely retaining any of its characters, except its peculiar hardness. Its colour, brown, yellowish, or reddish brown, or brownish purple. Its form variable, sometimes shistose, sometimes of the texture of moss.

Lustre, 0.1. Transparency, 0.1.

Fracture, splintery; earthy; or in the gross, slaty; often discovering granular distinct concretions.

Hardness, from 8 to 10. Specific gravity, variable.

The specimen, Leske, S. 1716, is of an Isabella yellow. Its lustre, 0. Transparency, scarcely 1. Fracture in the gross, slaty; but of the single laminæ, earthy; with minute reddish ochry spots. Hardness, nearly 9. Specific gravity, 2,602. It seems debased by a mixture of ochry argill.

The specimen, O. 322, is reddish brown, with whitish striæ, and red veins. Its lustre, 1; transparency, 0; hardness, 10.

Sometimes it shews a metallic lustre, yellowish, reddish, or greenish, from the decomposition

position of pyrites lying on its surface, as in Leske, O. 344.

Sometimes it hath an open spongy moss-like structure, destitute of lustre and transparency, as in Leske, S. 783, which is partly blackish, and partly yellowish ochry brown.

Sometimes it is so porous and earthy, as well as ferruginous, as to resemble porous lava, as in Leske, 744, destitute of lustre and transparency, but hard as 10.

Sometimes it is so cariated by calx of iron and argill that penetrates it, as to resemble slightly compacted rust, as in S. 28. Its colour is reddish brown. It is friable between the fingers.

Sometimes overlaid by calx of iron, as in Leske, O. 355, which exhibits quadrangular impressions of fluor crystals anciently contained in it.

Sometimes it has the appearance of a reddish grey, or greyish red, or yellow mortar, as in O. 1021 and 1733; or yellowish red, as in S. 270.

Sometimes it appears as if passing into sandstone, as in Leske, S., whose colour is greyish red, its lustre, 1; transparency, 0; hardness, 10; fracture, fine splintery, nearly even. See Leske, S. 1120.

Earthy Quartz.—This is often so disguised as to be easily mistaken.

The specimen, Leske, O. 360, is almost perfectly white. Its lustre, scarcely 1; transparency, 1; its structure as loose as that of moss, which it resembles; exceedingly brittle, and light as pumice.

2nd,

2d, The specimen, O. 414, is dark grey; lustre and transparency, nearly 0; consists of minute grains compacted together with numerous minute interstices; yet its hardness is 10; resembles sandstone, and N. 434, still more.

3d, In the specimen, O. 1383, we find quartz destitute of lustre and hardness, and of a yellowish grey colour, and splintery fracture; it differs from siliceous shistus in having no tendency to a slaty structure.

4th, The olive green quartz, Leske, 744, hath very little lustre, but some transparency; its fracture, splintery, seems passing into hornstone, but its texture is still too granular to suit this species.

5th, The specimen, Leske, S. 800, presents thin plates or laminæ variously heaped together, destitute of lustre and transparency; but their hardness proves them to be quartz.

6th, In the specimen, S. 1235, we may observe a yellowish white quartz, with distinct gross granular concretions, almost entirely destitute of lustre; but its transparency unhurt, being 2.

The earthy quartz, Leske, S. 1267, is of a grey colour, with a slight tinge of red and yellow; its lustre is scarcely 1; fracture, splintery, in the gross, slaty, with minute distinct granular concretions, resembling a close-grained sandstone; its hardness, 10.

The specimen, S. 1272, resembles the foregoing, but its grain is more open, and has more the appearance of slate.

Sometimes it hath a strong tendency to a laminar structure, as if passing into felspar, as in Leske, O. 422.

Some-

Sometimes it hath the lustre, and somewhat of the appearance of pitchstone, as in Leske, O. 422.

Sometimes its fracture approaches to the earthy, as in Leske, S. 1156, whose colour is bluish grey. Kärsten calls it a siliceous shistus passing into quartz.

Earthy Quartz penetrated with yellowish green Actinolite. S. 1310.——Greenish grey with yellowish green lumps, and specks and blotches of red.

Lustre, 1. Transparency, 1, or 0,5.

Fracture, splintery and uneven.

Hardness, 10. Specific gravity, 2,883.

It has numerous rifts, the sides of which present ferruginous illinitions.

Earthy Hornstone.—It scarce differs from earthy quartz, but, in possessing a finer and closer grain, it often contains some glimmering particles which are thought to be felspar. Hardness, from 7 to 10. Of this sort is the specimen, Leske, O. 454, which is of a reddish grey colour, mixed with green; its lustre and transparency, 0. Fracture, fine splintery. Structure thick slaty. Hardness, 10.

The specimen, S. 239, is nearly black, or brownish black. Its lustre and transparency, 0. Fracture, tending to the conchoidal, with a close grain. Hardness, 7.

When hornstone is in some measure decomposed, it discovers, in the same specimen, the characters both of an earth, and those that belong to its stony state. Thus in that, Leske, S. 417, which is pale grey, mixed with red and yellow, we see both a conchoidal and earthy fracture. Its lustre and transparency, 0. Hardness, 9.

Sometimes it hath the appearance of mortar, mixed with compact parts of a closer grain than quartz, as in Leske, S. 494, which is of an ash grey colour; the hardness of the more compact parts is 10.

The dark greenish grey is often the basis of porphyry, see Leske, S. 457.

Mountain green hornstone is often debased, apparently by green earth; of this sort is the specimen, Leske, K. 83. Its lustre and transparency, 0. Hardness, from 7 to 8. Its fracture imperfectly conchoidal. Gives a white streak.

Ferruginous Hornstone.—The peculiarities of these stones will best appear from the description of a few of them.

1. The specimen, Leske, S. 238, is reddish brown. Lustre and transparency, 0. Fracture, flat conchoidal. Very close grained. Hardness, 7. Gives a pale red streak.

The iron shot hornstones are more prone to melt than others; thus the greenish grey hornstone, Leske, S. 831, whose lustre, 0; transparency, 0,5, fracture, uneven and fine splintery; hardness, 9; specific gravity, 2,813; melted at 146°,5 into a black compact glass. When decomposed it has frequently the appearance and fracture of an ill-burned brick, as in Leske, O. 1105, which is pale yellowish red; hardness, 9 or 10.

The greenish grey hornstone, Leske, S. 1255, is at once earthy and ferruginous. Its lustre and transparency, 0; fracture, coarse splintery; in the gross, slaty; hardness, 10; it is covered with a red ferruginous crust, which in some places sinks pretty deep into its substance.

But the reddish calces of iron give no tendency to fusion. Thus the purplish red hornstone, Leske, G. 61, whose lustre and transparency, are 0; fracture, uneven, but fine splintery; hardness, 9; specific gravity, 2,638, refused to melt, but barely hardened at 147°,5 into a dark grey mass.

Siliceous Shistus penetrated with Argillite.—Colour, light bluish grey, or purplish grey.

Lustre, 0. Transparency, 0.

Fracture, fine splintery; in the gross, slaty.

Hardness, 9 or 10. Specific gravity, 2,689, but may vary with the kind of argillite.

Of this sort is the specimen, Leske, S. 993, whose colour is bluish grey; also that in Leske, G. 174^{b}, which is purplish grey, streaked in the fracture with yellowish grey, and has some resemblance to a sandstone. The specimen, S. 993, had its specific gravity, 2,689, and at 148°, melted into a greyish white porcelain, which was glazed at the surface. Leske calls this a slaty hornstone: Kärsten a siliceous shistus. Its fusibility, texture, and grain, induce me to suspect it contains grey argillite.

Siliceous Shistus, penetrated with Mullen. Leske, S. 1246.—Bluish grey, its surface often stained reddish and yellowish brown.

Lustre, 0; transparency, 0.

Fracture, fine spintery, and uneven.

Hardness, 8; specific gravity, 2,739.

At 148° the specimen, Leske, S. 1246, melted into a yellowish black, and somewhat porous porcelain.

Siliceous Shistus, penetrated with Limestone. Prasiform Porphyry of Kärsten. Leske, S. 1811.—Dark, somewhat yellowish grey.

Lustre, 0, except a very few particles; transparency, 0.

Fracture, splintery; the grain very fine and close.

Hardness, from 9 to 10; specific gravity, 2,578.

Though Kärsten reckons it a shistose porphyry, I can perceive no traces of felspar. The whiter spots are evidently nothing else than semi-transparent splinters.

Pitchstone, penetrated with Opal. Leske, S. 295.—Pearl grey, somewhat resembling porcelanite.

Lustre, silky, 2; transparency, 1.

Seams penetrated with lumps of opal.

Hardness, 8. Brittle. Specific gravity, 1,970.

Imbibes water slowly.

Heated, it decrepitates strongly, and then whitens; at 148°,5 it remained a loose powder.

Granite, penetrated with Argillite. Leske, S. 1883.—Whitish and purplish grey.

Lustre, 1. Transparency, 0, or 0,5.

Fracture, partly splintery, and partly obscurely foliated.

Hardness, 8, very difficultly broken; specific gravity, 2,670.

The mica and purplish argillite are very perceptible.

FIRST APPENDIX.

DIAMOND.

Its colour is most commonly pale grey, which often passes into the yellow, sometimes citron yellow, seldom rosy red, still more rarely green or blue, but very often pale brown, or colourless.

It occurs most commonly in rounded grains, seldomer in double quadrangular pyramids, or flat double triangular pyramids, whose edges are convex, &c.

Its external lustre casual, internal, 4. Its transparency, 2.3.4.

Its fracture foliated. Fragments, 4.

Its hardness, 20. Its specific gravity, from 3,44 to 3,55.

It gives but a single refraction.

In a heat of 35° or 40°, it consumes and burns like an inflammable substance; hence some think it a very pure species of coal. No acid has any effect on it.

SECOND APPENDIX.

Of Stones and Earths that owe their Origin to Fire.

The fires from which many minerals derive their form and aggregation, are either volcanic or pseudo-volcanic; of each of which we shall successively treat.

CHAP. I.

§ I.—*Of Volcanos in general.*

A VOLCANO is a mountain that ejects smoke, flame, and heated stony substances, partly in a loose, partly in a solid, and partly in a liquefied form.

These mountains generally stand single and detached; yet we are told, that in Peru, and frequently in Kamschatzka, they form part of an extensive chain. With these, however, we are as yet but imperfectly acquainted, and it is not clear, that most of those that are so called are not rather pseudo volcanos.

Every volcano hath therefore necessarily an aperture, or mouth through which this fiery matter is discharged; this aperture is called its *crater*, generally it is placed in the summit of the mountain, but sometimes on its sides. The aperture on the summit is, however, most frequently so called, as it is more commonly open, and is formed of materials that, after having been ejected, have fallen on the borders of the aperture, and in succession of time have formed a sort of chimney all around. The lateral aperture is commonly blocked up by the last portions of the liquefied matter that have flown through it. The crater is always of considerable extent, often of many miles in circumference.

The ejective power of volcanos is now generally believed to proceed partly from air, passing from a concrete into an elastic state; partly, and indeed principally, from water and bitumen, converted into steam; and often also from the decomposition of steam: the cause of this decomposition is easily understood by those who are acquainted with the discoveries of Mr. Lavoisier and Dr. Priestley.

The liquefied matter that issues from volcanos is generally called *lava*, from the Gothic *Lopa*, or *Lauffen*, to run. The heat communicated by volcanic fire, to the immense mass of materials on which it operates, scarce ever equals 120° of Wedgwood, and still more rarely exceeds that degree; this is evident from its effects; for, limestones are frequently ejected from volcanos uncalcined *, and yet their calcination requires only a heat of 120°, and shorls, which are fusible at 95°, are ejected, unfused, and unaltered; so also are stones of the nature of trap, which yet vitrify in a heat of 120° or less.

The most diligent and exact observers of volcanic eruptions agree in testifying this fact. Desmaretz, Mem. Par. 1771, p. 830, in octavo, tells us, "the experiments of Mr. D'Arcet "prove the fire of volcanos to be commonly "much too weak to produce perfect vitri-"factions."

Mr. Dolomieu, in the preface to his observations on the Pontian Islands, p. 8, says, "vol-"canic fires have no intensity, they cannot vi-"trify even the most fusible substances, such as "shorls." And, in his Notes on Bergman's Treatise on Volcanic Products, he affirms, that, "volcanic heat neither alters the texture, co-"lour, density, or hardness, of many of the "substances that are exposed to it." P. 162. Others give in effect the same testimony, by attesting the slowness with which lava commonly flows. Thus, in the famous eruption of 1636, the lava of Ætna moved only at the rate of three miles in 24 hours, or about 3,6 feet in a minute, though several feet in height, and one of the quickest of which we have any account *.

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* Dolom. Notes on 3d Bergm. p. 77.

The lava of Vesuvius has often continued in motion for years; and that of Ætna has continued to flow for ten years, and not more than at the rate of six feet in a day †. Now there are but three sorts of fusion, with which we are acquainted; that which produces porcelain, that which produces enamels and semi-vitrifications, and that which produces glass; by inspecting lava, we shall find that very little of it has been in any of these states; since, therefore, it has flowed, it is plain, it has derived it liquefaction not from the fusion of its own materials, but from that of some foreign substance mixed with it. This fact is so plain, that it has even struck Mr. Dolomieu, in the midst of his prepossessions in favour of some strange inconceivable power which he attributes to volcanic fire, of melting earthy substances without effecting any alteration in their sensible qualities. " I hope (says he), to prove that lavas contain " in their interior a combustible matter, which " burns and consumes in the same manner as " other inflammables." *Isles Ponces*, 10. Yet he neglects telling us what this matter is; though it plainly appears to be no other than *sulphur* and *bitumen*, of which an immense quantity is found in all volcanos, which liquefies in a low degree of heat, and causes all the stony substances to flow, that are immersed in it. Mr. Fabroni, in his masterly treatise on coal, p. 3, tells us, that recent lavas are, as if it were, anointed with petrol. Mr. Bergman, indeed, denies that any sign of it appears on lavas, §. 9. But Dolomieu, in his notes on that section, establishes the fact. "Recent "scoriæ, which cover lavas, often give une"quivocal indications of petrol; they are "greasy, sooty, unctuous, and detonate with "nitre, but these indications soon vanish."

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* 2 Phil. Trans. Abridg. p. 387.

† Dolom. *Ponces*, 12. 66.

Mr. Fougeroux made the same observation; Mem. Par. 1766, p. 42, in octavo. Mr. Guethard; Mem. Par. 1752, p. 76, concurs. Von Salis, in his account of Sicily, published in the year 1790, tells us, that he found in it whole mountains of bitumen, coal, and bituminous wood; p. 68 and 69; and some under beds of basalt, which he calls lava.

Hence we have all the proof that can be expected, that lavas owe their liquedity to melted bitumen, and sulphur; which at once explains why they are so little altered from their primitive state, why they are magnetic, as their iron is in contact with imflammable matter, and the reason of their uncommon fertility when in a state of decomposition, as they retain much of the carbonic principle, which is the food of plants, and is set loose by their decomposition.

To present a clear idea of volcanic eruptions, I shall quote the description given by Mr. Dolomieu, *Ponces*, 278, who has observed more of them in various circumstances than perhaps any other person. "After repeated concus"sions and subterraneous thunders have an"nounced the labour of a volcanic mountain, "the smoke issuing from its summit augments; "it is sometimes black, sometimes white, and

" so thick as to appear almost compact." (Here I must remark, that this black smoke, such as we see issuing from glass-houses, is an evident proof of the accension of coal and bitumen laid on fresh). " It rises in perpendicular columns, " to a great height, then becoming too heavy " to be supported in so rare a part of the at- " mosphere, it spreads and forms a head like the " summit of a pine; flame appears soon after, " and this is succeeded by projections of ashes, " scoriæ, and inflamed stones; at last, from " the bottom of the crater, a liquid matter rises " resembling melted metal, whose surface is in " a state of combustion." Here the bitumen exposed to the open air, burns off, and hence scarce any traces of it are afterwards found. It even appears doubtful to me, that there exists any flame at the bottom of the volcano, as the air is generally too impure to support it. " This matter flows down from the lowest bor- " der of the crater, and is covered with a quan- " tity of scoriæ, which float on its surface, " being very thick, it flows slowly, scooping a " cavity in the light scoriæ, that form the ex- " terior of the cone, and attaching those scoriæ " to itself, it descends gently, and then spreads. " Its farther progression is made either by roll- " ing on itself, the upper part becoming the " lower; or by issuing from under the scoriæ " which cover it; this last mode is the most " usual; for, the surface of the current being " covered with scoriæ, and congealing with " them, and with the earth on both sides, forms " a kind of crust, under which the lava flows " as under a bridge. An eruption of this kind " may flow for a long time and furnish nothing " but porous lava. Rarely there are any cur-

"rents of compact lava. In Ætna the lava "seldom issues from the summit, but generally "from the sides of the mountain, in rivulets "which afterwards unite in one common torrent. Sometimes these lateral ejections are "made with immense force, and project enormous stony masses half a league. The currents that issue from the sides of a mountain, "are generally more compact than those that "issue from the summit; they would even be "exempt from scoriæ, and porous lava, had it "not been for an internal effervescence, which "takes place in them. After the excavation "of the ground by the first ejection, the progression becomes slower, and the lava is covered with a white and bluish flame. Sometimes it flows like an expanding ribband, and "then the upper part becomes lowest, and consequently buries the scoriæ and cellular lava; "at other times a new head issues from under "the hardened surface. Thus the lavas envelope and carry with them the bodies they "meet; and thus they are associated with the "porous lava."

§. II.—*Of Volcanic Productions.*

1st, Of Lavas in general.—Any matter that has issued out of a volcano in a liquefied state, or that has accompanied, or been enveloped in such liquefied matter, is in general styled a *lava*; and of this three sorts have been remarked, the vitreous, the cellular, and the compact.

2nd, Of Vitreous Lavas.—Vitreous lavas are formed of such matters as have been exposed to the greatest heat, or which, from their composition, were most susceptible of vitrification in a moderate heat.

Their colour black, greyish black, dark green, yellowish, or greyish white; generally found in inconsiderable and detached masses, either frothy, or compact.

Their lustre, 3; transparency, 3.2.1.; fracture, conchoidal.

Hardness, from 9 to 10.

Specific gravity, variable, from 2 to 3; according to their more or less frothy, porous, or compact state, and also to their composition.

Mr. Bergman has given us the analysis of a glass of this sort from the *Lipari Islands*, which contained 69 per cent. of silex, 22 argill, and 9 of iron. 3 Bergm. p. 204. In another, he found 49 per cent. silex, 35 argill, 4 calx, and 12 of iron. De Prod. Volcan. 1st edition.

But all these results are evidently fortuitous, as the compositions must ever vary, with those of the original stones or earths that are vitrified.

3d, Of Enamels.—Analogous to vitreous lavas are the imperfect vitrifications called *enamels*.

Their colours are white, grey, or brown, often with round spots of a different colour from the ground. Lustre, 2.3. Transparency, 0.

Fracture, rather more granular than that of glass, or between that and the porcelain grain.

Hardness from 9 to 10. Specific gravity, approaching to 3, often higher.

Sometimes contain crystals of shorl, or felspar, not completely melted.

4th, Of Volcanic Scoriæ.—These are compounds of iron and stony matter that owe their fusion to sulphurated iron, which is known to be much more fusible than iron in any other state; they are tumefied and expanded by the sulphureous vapours, and commonly invest the surface of cellular lava, as sulphur can burn only where in contact with the air.

Their colour is generally black, but sometimes reddish, from the calcination of the iron.

Their surface rough, uneven, and tumefied.

Lustre, 2.3, when decomposed, 0. Transparency, 0.

Their texture cavernous, the cavities larger and more irregular than those of cellular lava, but never fibrous.

Their hardness from 7 to 9, very brittle.

Their specific gravity, when they are very porous, is often such as to admit them to float in water; but, when well soaked in it, their specific gravity generally exceeds 2,7.

Mr. Dolomieu found at least 8 per cent. of iron in all those he examined, and generally more. Crystals of felspar, white garnet, and basaltine, have been found in them. They all resemble each other. Ponces, p. 147.

Besides the scoriæ that accompany beds of lava, there are others, thrown out in detached masses. These mixed with volcanic ashes form the crater of volcanos; they are generally more completely vitrified, and though more tumefied than other scoriæ, yet they sink in water, as they are more easily penetrated by it. They are mostly of the size of a nut, and readily moulder by exposure to the air. At Naples they are called, *rapillonero*. Dolom. p. 203.

5th, *Of Volcanic Slaggs.*—These entirely resemble the dross of forges; they are generally red, and heavy.

§ III.—*Of Cellular Lava.*

Its colour is brown, or reddish brown, or greyish black, seldom grey.

Its surface, unequal, rough, and full of cavities.

Its lustre, 0. Its transparency, 0. Its fracture earthy, and full of cavities.

Its hardness, from 7 to 9. Its specific gravity variable with its porosity, but does not exceed 2.8.

Mr. Dolomieu pretends, that its internal pores distinguish it from porous stones of Neptunian origin. Notes on 3 Bergm. p. 184. These pores are larger near the surface, than towards the centre. Ponces, 295.

It is more subject to destruction than compact lava; yet no compact lava is ever found wholly destitute of the cellular. Ponces, 277.

It generally affects the magnetic needle.

§ IV.—*Of Compact Lava.*

By compact lava, volcanic writers denote an earthy substance, which, after having been fused but not vitrified, becomes, on cooling, compact, close, and solid.

Whether this degree of solidity is such as *totally* to exclude that evidently porous and cavernous structure, which cellular lava presents, is not perfectly agreed upon.

Those who are guided by observation on modern and undisputed volcanic torrents, allow that no lava absolutely compact, and destitute of pores in an extent of more than a few square inches is ever found. Thus Mr. Bergman defines compact lavas to be, "those which, "though not absolutely destitute of cavities, "yet contain so few, that they may be cut "into slabs with an almost entire surface, and "polished like marble." 3 Bergm. p. 201. To this definition, Mr. Dolomieu, in his Notes on Bergman's Dissertation, makes no objection; from which we may conclude, that in a small extent, such as that of common marble slabs, they never exhibit an uninterrupted surface. This last-mentioned philosopher, indeed, having unfortunately wished to comprehend, in his definition of compact lava, stony masses, not found in modern and undisputed beds of lava, but in *supposed* ancient currents, found himself much embarrassed: "there is (says he), such "uncertainty in the characters of compact "lava, that, independently of local circum"stances, the most experienced eye may be de"ceived[*]." Yet these circumstances, not properly attended to, are those which have seduced him into the most palpable mistakes.

Gioeni, though in many instances misled by Dolomieu, yet acknowledges that lava, so compact as to be totally destitute of pores, is not found. Litholog. Vesuv. p. 85. Padre Torre, who, independently of any system, has candidly and impartially examined the products of Vesuvius, expressly denies the existence of lava destitute of pores, none other but the porous being found in currents of modern date[†]. Galeani, in his catalogue of the lavas of Vesuvius, drawn up in 1772, hardly mentions any compact lavas. Gioeni, in his catalogue, entirely omits this distinction; and Mr. Dolomieu acknowledges, that not a single specimen of compact lava is to be found in the cabinet of Prince Biscari.

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[*] Ponces, 171. [†] Ponces, 174.

Those, on the other hand, who, guided by system, bestow the name of lava on stony masses, which they *suppose* to have anciently flowed, either from real still subsisting, or imaginary ancient extinct, volcanos, find *compact* lava entirely destitute of pores, very *scarce* indeed in the *supposed* currents from modern, but in *great plenty,* in those which they ascribe to their fictitious volcanos now extinct, as well as in the very bowels of those volcanos.

Gioeni, after telling us, from Dolomieu, that compact lava occupies the centre of the beds of lava, and porous lava the upper part, acknowledges that this gradation seldom takes place: "*few,* however (says he), are the visible currents of lava on Vesuvius, in which we meet this gradation." It seems he should rather have said *none;* for, some lines after, he tells us, "that modern volcanos have lost the power of producing any[*]." The detached masses that pass for compact lava, he acknowledges to have been ejected in their solid form by the explosive power of the volcano, and consequently are not real lavas, but rather natural stones, torn from the sides of the mountain[†]. Mr. Dolomieu tells us, that compact lavas are stones which, after having been melted, re-assume their natural state and appearance without any change in their external or internal

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[*] Lithol. Vesuv. L. LIII.

[†] Lithol. Vesuv. LI.

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properties, or scarce any change*; and that some are perfectly compact (that is, destitute of pores), namely, those that are buried under, not other lavas, but under an entire and immense volcano†; he therefore gives up the idea of finding these not only in the *beds* of modern, but even in those of extinct ancient volcanos. Hence he tells us, that they are much more common in extinct volcanos; and that in Ætna they do not constitute the $\frac{1}{000}$ part of the whole; whereas in Vivarois and Auvergne they form whole mountains. Now most of these ancient volcanos of the Vivarois appear to me, and many others, to be mere creatures of imagination, and consequently, until the substances they contain are proved to have been in fusion, no definition, grounded on the appearances of these substances, can pass for that of real compact lava.

In beds, however, of real undisputed lava some parts are found, that, having been pressed by the super-incumbent weight, are more compact than common porous lava; and these, comparatively to the former, may be called compact; but scarcely more than a few square inches of their substance is destitute of visible pores.

Their colour is brown, yellowish, reddish brown, bluish, or black, more rarely grey. Their lustre, 0.1. Transparency, 0.1.

Their fracture, earthy, or fine splintery, more rarely foliated, and present small internal pores, if of sufficient size, in some part of their substance.

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* De prodotti. Volcan. p. 162. Ponces, 170, &c.

† Ponces, 179.

Hardness, from 7 to 9. Specific gravity, 2,75 to 2,88.

Much circumspection is requisite, in framing a description of compact lava, from a view of the specimens brought to us from volcanic countries, as they are all collected by persons, who take indiscriminately from real, and from supposed, volcanic currents, even from mountains in which no volcano ever existed.

To form a true idea of these lavas, we should attend to the following circumstances:

1st, That the heat of most volcanos (I exclude those that for the most part produce only vitrified substances) seldom reaches 100°, of Wedgwood; the proof of which is, that almost all real lavas, whether cellular or compact, are vitrifiable at that degree. Since, therefore, they were not vitrified in the volcano, it is plain that in it they did not attain that degree; 90 or 95 degrees may then be assumed as the average heat of most volcanos.

2nd, In this heat, many stones of the argillaceous genus, as traps, hornblendes, and argillites, undergo a change; for they alter their colour, become porous, assume a porcelain grain, and consequently begin to vitrify, as I have found on repeated trials; but they never flow in this heat, nor consequently form a lava; but bitumen will flow in this heat, and even in one much inferior, and be decomposed. If, therefore, the argillaceous stones be mixed with, and drenched in, bitumen, they will be softened by it, and flow with it; and where the air erupting both from them, and the decomposing bitumen, has most liberty to escape, it will tumefy, burst through the liquid mass, and form cellular lava, but, where it is more compressed, less of it will be disengaged, and the lava will be compact, and resemble, in some degree, the original stone of which it is formed.

3d, Stones of the siliceous genus undergo no change in this heat, not even shorls or felspars; and hence, though immersed in the fiery torrent, they cannot with propriety be called lavas, as they are not even softened by the mixture of bitumen, as stones of the argillaceous genus are.

Between siliceous and argillaceous stones there are many gradations, and various mixtures, which must occasion corresponding varieties in the effects which heat, and various other circumstances may produce. It is sufficient here to establish the principles on which most of them may be explained. Compact lavas abound in heterogeneous substances which either have not been fused, or only partially fused, or scorched, or decomposed by heat, as felspar, shorls, garnets, zeolytes, &c. Every volcano has some that are peculiar to it. Thus the lavas of Vesuvius abound in that called white garnet, and which I call Vesuvian; those of Ætna abound in felspar, &c.

Hence we must exclude from the rank of lavas all stones which do not appear, either from their external characters, nor local circumstances, ever to have been softened by heat; and consequently all those detached pieces, which are ejected at the beginning of an eruption without fusion, and many others which volcanic collectors enumerate among compact lavas, merely from having found them in the vicinity of volcanos. Thus Mr. Dolomieu, Lipari, 85, reckons among volcanic stones one, in the interior of which he distinctly perceived a leaf of sea-weed. Few, indeed, are the stones contained in his catalogue which can be deemed really volcanic. P. 70, of the same treatise, he tells us, that the lava which burst from the sides of Ætna in 1669, had for its basis a granite *no way altered;* but, when he expressly treats of the products of Ætna, he tells us, *L'Ætna paroît n'avoir jamais traité le granite.*. The mistakes of this great man, for such I certainly hold him, have had so wide a spread, and have misled so many who have not had an opportunity of viewing volcanic countries, that I feel myself necessitated to detect them; a liberty, which I am persuaded, his candour and love of truth will readily induce him to excuse.

All real lavas except those of the vitreous kind, affect the magnetic needle, unless the iron they contain be much oxygenated, as it often is in those of a red colour, but even these are frequently magnetic by reason of the shorls embodied in them.

The component ingredients of lavas are various, according to the nature of the original stones, and the accidents they meet with in their liquefied state. Mr. Dolomieu found them to contain from 40 to 60 per cent. of silex, from 16 to 3 of magnesia, from 5 to 1 of calx, and from 6 to 25 of iron. Ponces, 184.

§ V.—*Of Volcanic Ashes, Sand, Pouzzolana, Trass, Tufa, and Piperino.*

1st, *Of Volcanic Ashes.*—Their colour is brownish or reddish grey.

Of a loose and dusty consistence, very light and subtle, and smooth to the touch.

Slowly diffusible in water, and when wet somewhat ductile.

They effervesce slightly with acids, and contain about half their weight of argill, a small proportion of calx, magnesia, and iron; and the remainder is siliceous

In different volcanos, nay in different eruptions of the same volcano, the properties differ. Magnetism in them is merely casual, few of them possess it. Dolom. on Bergm. p. 26.

Though Dolomieu, Ponces, 337, thinks these ashes have no resemblance to those of common inflammable substances, yet, as well by their external appearance as by their analysis, they appear to me exactly the same as those that proceed from various sorts of coal. From what else but the combustion of coal, could the thick black smoke arise which always precedes the eruption of ashes? surely not from the combustion of sulphur or pyrites! All volcanos contain coal and bitumen, whose combustion must produce ashes. Immense quantities must be consumed before lava can be formed; and hence ashes always precede lava.

Volcanic sand consists of minute hard grains, that readily sink in water, generally fragments of lava and scoriæ, together with olivin, garnets, felspar, and shorl. Dolomieu. Ibid.

*2nd, Of Pouzzolana**.—Reddish, or reddish brown, grey, or greyish black. That of Naples is generally grey, that of Civita Vecchia more generally reddish, or reddish brown. Dolomieu's Notes, 32.

Its surface, rough, uneven, and of a baked appearance. It comes to us in pieces of from the size of a nut to that of an egg.

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* 34 Mem. Stock. 27, and 31. Gioeni LXVI. Dolom. Notes, 32.

Its internal lustre, 0. Its transparency, 0.

Its fracture uneven, or earthy, and porous, commonly filled with particles of pumice, quartz, scoriæ, &c.

Hardness, 3. Very brittle. Specific gravity, from 2,570, which is that of the black, to 2,785, rarely 2,8. Has an earthy smell.

It is not diffusible in cold water, but in boiling water it gradually deposits a fine earth. It does not effervesce with acids.

Heated it assumes a darker colour, and easily melts into a black slagg, or with borax into a yellowish green glass.

It is magnetic before it is heated, but not after. This is the most remarkable of its properties.

By Mr. Bergman's analysis, it contains from 55 to 60 per cent. silex, 19 to 20 of argill, 5 or 6 of argill, and from 15 to 20 of iron. 3 Bergm. p. 194.

When mixed with a small proportion of lime it quickly hardens, and this induration takes place even under water. This singular property appears to me to proceed from the magnetic state of the iron it contains, for this iron being unoxygenated, subtilly divided, and dispersed through the whole mass, and thus offering a large surface, quickly decomposes the water with which it is mixed, when made into mortar, and forms a hard substance analogous to the specular iron ore as it does in the iron tubes, in which water is decomposed, in Mr. Lavoisier's and Dr. Priestley's Experiments. For in these the iron swells and increases in bulk. Mem. Par. 1781, p. 277. And so does pouzzolana when formed into mortar. Higgins on Cements, 125. One principal use of lime seems to be to heat the water, as while cold it cannot readily pervade the caked argill that invests the ferruginous particles, yet in time even cold water may pervade it, and produce hardness; and hence lavas become harder when moistened, as Mr. Dolomieu has observed. Ponces, 417. If the mortar be long exposed to the atmosphere, fixed air, as well as pure air, will unite to the iron, rust will be produced, and the mortar will not then harden, as Dr. Higgins has also noticed. Clay over which lava has flowed, is frequently converted into pouzzolana. Ponces, 332. But volcanic scoriæ never afford it; ibid.; either because they are much calcined, or retain sulphur, or its acid.

3d, *Trass, or Terras**.—I couple this with pouzzolana, on account of their similarity to each other, and not because I look upon it as constantly, and necessarily, a volcanic production. On the contrary, I believe it to be generally the product of pseudo-volcanos, or external fires.

It is found in many places, but principally near Andernach, in the vicinity of the Rhine; also near Frankfort, Cologne, Pleith, &c. and there called tuffstein.

Its colour is grey, brown, or yellowish.

Its surface rough and porous.

Its lustre and transparency, 0.

Its fracture, commonly earthy, rarely lamellar; it contains fragments resembling pumice (though not real pumice, Voight, *Fuldæ*, 221); also fragments of argillite and basaltine; often branches of trees half cleared, and impressions of leaves. 2 Nose, 182. Mica, iron ore, and other heteregeneities, are more frequent in it than in pouzzolana. 3 Bergm. 196.

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* 32 Mem. Stock. 51.

Its hardness, from 5 to 7.

Feels dry and harsh. Scarcely effervesces with acids.

It is not diffusible in cold water, but in hot it gives an earthy smell, and deposits a finer earth.

It melts into a greyish brown slagg.

It is found in valleys some feet under the surface, to which no streams of water have had access. Sometimes in columnar masses of a grey, or Isabella yellow colour, some round and some quadrangular, standing close to each other, and forming internally one common mass. 3 Berl. Beob. 199.

According to Mr. Bergman, it consists of nearly the same principles as pouzzolana, only the calcareous seems more plentiful in this.

Artificial terras, or pouzzolana, is made by burning clays or slates that bound in iron, and then grinding them to a fine powder.

*4th, Tufas**.—These seem to be a pouzzolana formed by nature into a mortar.

Their colour, brown, or reddish brown, brick red, or speckled with various colours, or green.

Lustre and transparency, 0.

Fracture, earthy, contain sand, scoriæ, fragments of lava, limestone, and pumice, often basaltines and Vesuvian. Hardness, 6.

Commonly magnetic, and not easily decomposed by the action of the air.

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* Gioeni LXXVII., and 174. Dolom. Notes, 34, and 233.

5th, *Piperino*[*].—This also seems a concretion of volcanic ashes, and is said to be the substance that covers Pompeia.

Its colour, grey, or reddish brown. Its lustre and transparency, 0.

Its fracture earthy, contains fragments of white marble, felspar, mica, garnets, scoriæ, gypsum, shorl, granite, &c.

Its hardness, 6.

Sometimes magnetic, sometimes not.

It seems to differ from tufas, in containing more heterogeneities, being in fact a kind of porphyry or breccia, and being more easily decomposed by exposure to moisture and the open air, but if preserved from moisture it hardens when exposed to the air.

6th, *Pumice*.—1*st Variety*.—Its colour grey, or greyish white, rarely brown, or blackened by fuliginous fumes.

Its surface rough and fibrous, with elongated pores.

Its lustre glassy, 2. Transparency, 1.2.

Its fracture striated and open. Fragments, oblong and obtuse.

Its hardness, 3. Brittle in a high degree. Specific gravity, below 1.

2*nd Variety*.—Its colour grey, or brownish grey, rarely red.

Its surface rough and dull, with exceeding minute pores. Its fibres not discernible.

Its lustre and transparency, 0.

Its fracture, uneven and splintery. Fragments irregular and obtuse.

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[*] Dolom. Notes, 34, and 233.

Its hardness, 3. Specific gravity, 0.

Both are fusible at 130° into a grey slagg. 2 Gerh. Gesch. 42.

Mr. Dolomieu mentions two other varieties heavier than water, and considerably harder than these. I should rather call them pumiceous mixtures; he does not describe them.

§ VI.—*Of Stony Substances ejected, unaltered, or but slightly injured.*

Not only shorls and garnets have been ejected from volcanos unfused, but even calcareous and fluor spars, with their transparency unimpaired*; which could not happen if they had been exposed even to the lowest red heat; we must suppose them, therefore, to be expelled by the mere force of the exploding elastic fluids, whose power is fully equal to such an effect, since when confined they shake, agitate, and convulse whole mountains.

Earths of the argillaceous and muriatic genera exposed to the slighter degrees of heat, as clays and steatites, are barely hardened; and stones of these genera lose their lustre and transparency. In a greater they become porous. Stones of the siliceous genus also lose their lustre and transparency, and become brittle.

Granites have been found in beds of lava in different states; those on the surface of the bed have had their felspar somewhat altered, being there exposed to actual flame. But those in the centre, having never been in fusion, are only rendered more brittle†.

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* Dolom. Notes, 227. † Dolom. Notes, 76.

In the same manner *porphyries* have been involved in beds of lava, even porphyries that have hornblende for their basis, without having thereby suffered any alteration*; an evident proof of the low degree of heat which generally prevails in volcanos.

In vain have some philosophers of late attempted to account for these appearances, by ascribing them to the fusion of granites and porphyries under an immense pressure.

Before an effect can with any degree of probability be ascribed to a given cause, the existence of that cause must either be *certain*, or at least *probable*; and the cause, if it does exist, must be known to be adequate to the effect ascribed to it. Now the above assertion is incompatible with both these maxims; for, first, the existence of a degree of heat, sufficient to melt the immense existing masses of granite, has never yet been proved, nor has the slightest inducement, even to suspect it, ever yet been offered; on the contrary, it is repelled, and glaringly contradicted by every phenomenon.

Secondly, if such a heat could be proved to exist, this would not be sufficient; the existence of a pressure, sufficient to stifle the eruption of all the elastic fluids it would tend to evolve, should also be proved: how can it?

Thirdly, If all this were evident, still such a cause would be inadequate to the effect; in granite three or more distinct species of stone adhere, unmingled with each other. Is this the effect of any fusion of stony matter ever yet observed? have stones, one of which is a flux for the other, ever yet remained separate, though both in fusion?

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* Dolom. Notes, 76.

After all, why thus war with all known experiments and analogies? No other cause is assigned but the *supposed* origin of basalt from fusion, and the near approach of this stone to granites. "Notwithstanding (says Dr. Beddoes) the recent objections of Mr. Werner, "I shall assume the origin of basaltes from "subterraneous fusion, as thoroughly esta-"blished by various authors," and the near approach and connexion of basalt with granite; that both have had the same origin, that is have been produced by the same natural cause, I shall not dispute; but that basalt was never actually fused, will clearly be seen in a subsequent section.

CHAP. II.

OF PSEUDO-VOLCANOS, AND SUPERFICIAL FIRES.

PSEUDO-volcanos are so called, because, like volcanos, they emit smoke, and sometimes flame, but never lava, in which respect they differ from true volcanos. Most of these are coal mines which have accidentally taken fire; some appear, however, to be natural, as several in Kamschatzka and Peru. In Europe these pseudo-volcanos are not uncommon. Thus a coal mine in the mountain of Fontaynes, in Rouergue, having taken fire in 1770, has continued to emit smoke and flame and sulphureous fumes ever since. Mem. Par. 1781, p. 201. Sulphur has been sublimed from it; for it is found on the trunks of trees growing on its surface, and also crystallized sal-ammoniac.

The mountain of Cransac has continued burning ever since the year 1400. In the mountain of Scadaliá another pseudo-volcano, near that of Cransac; for springs have been formed, some of which have now lost their heat, as the fuel which occasioned it has been consumed. Mem. Paris. Ibid.

These mountains not only produce sulphur, sal-ammoniac, and other salts found in true volcanos, but also tufas, scoriæ, and porous lava. Ibid. 224. And also tripoli and pouzzolana.

Superficial combustions are not uncommon, and produce singular effects, which have often been mistaken for those of true volcanos. Among others, columnar argillaceous iron ore, slates converted to slaggs, and others, with vegetable impressions.

CHAP. III.

OF THE DISTINCTIVE CHARACTERS OF VOLCANIC AND NEPTUNIAN MOUNTAINS.

THESE are taken from the form and arrangement, or from the nature of the materials of which these mountains are formed.

The peculiarities of volcanic mountains are, 1st, That they stand single and unconnected, are of a conic form, and are furnished with an opening of the shape of a funnel, or inverted cone, called the *crater*.

2nd, A total absence of stratification near the crater, for here the volcanic cinders, scoriæ, and ashes mixed with sulphur, and indurated, lie in confused heaps.

3d, A stratification, where any is found, peculiar to volcanos, that is unequally diffused and confusedly arranged; for this stratification, such as it is, arises from the liquid matter ejected by the volcano at different periods. Now, at each period the matter gradually cools as it descends; none but the hottest part extends to a great distance; and hence it is always densest where nearer to the crater or opening from which it issues, than at a great distance from it; and the lavas of different periods, being unequally heated, must be diffused in a manner very different from each other, and constitute beds of very unequal densities. Besides, the cone itself being formed by a long succession of eruptions, the first having met with little or no declivity, have remained near the mouth of the volcano. Moreover, eruptions from the sides of the cone often happen, which bursting through the former beds of lava, occasion a still greater irregularity in the general arrangement.

4th, The form of a bed of lava is always narrower near the crater, or mouth from which it burst; for it expands as it proceeds to a greater distance.

5th, Metallic veins are never found in beds of lava, nor indeed veins of any kind, at least of any extent, being incompatible with the confusion that reigns in them. Now Ætna is said to contain veins of various metals, the part that contains them is therefore not of volcanic origin.

Again, the substances peculiar to volcanos are those of volcanic origin; many of them, however, may owe their production to pseudo-volcanos, as we have seen; and therefore, if local circumstances be not also attended to, may occasion considerable mistakes. These substances are pumice, volcanic ashes, pouzzolana, tufas, piperino, vitrifactions, porous and compact lavas, each of which should carefully be examined to distinguish it from other substances produced in the moist way, which at first sight may be found to resemble it.

1st, *Pumice;* this, of all substances, is most peculiarly appropriated to volcanos, particularly that of the first variety; yet sometimes a compacted congeries of felspar, and shorl crystals with some scales of mica, have been mistaken for it; 2 Nose, p. 183; nor is mere floating on water a sufficient character whereby to distinguish pumice, for various porous lavas float on water; Fauj. Mineral des Volcan. 265; so also do the scoriæ of some slates which also have a greenish grey colour. 1 Sauss. 78. It should also be remembered, that pumice, as it floats on water, may be conveyed from a great distance.

2nd, *Volcanic ashes;* these, when indurated, much resemble wacken; and accordingly this last has often been taken for them. Mr. Dolomieu has fallen into this mistake in his description of Lipari, p. 57, as must be evident to any impartial person that considers it. Others have taken comminuted argillite for volcanic ashes. 2 Nose, 158.

3d, *Pouzzolana;* decayed traps, or trap porphyries, particularly when compacted with clay, much resemble pouzzolano, and often answer the same purposes; therefore they have often passed for it. See 1 Nose, 64, 65; 2 Nose, 74, 11; Nev. Entd. p. 69; and Leske, G. 209, 221.

4th, *Tufas;* wacken has been sometimes taken for these.

5th, *Piperino;* amygdaloids, out of which their kernels had fallen by decay, sometimes resemble this stone; so also do decayed traps, or basalts. 1. Bergbau, 398.

6th, *Vitrifactions;* hyalite, otherwise called muller's glass, has passed upon many as a product of heat, though infusible at 150°; glittering fragments of felspar bear often a deceitful resemblance to glass.

7th, *Porous Lavas;* amygdaloids with a trap basis, and argillites, often resemble these so strongly, that Mr. Saussure, who found some on the Alps, owns he would have taken them, if he met them elsewhere, for genuine lavas. 1 Sauss. p. 142, 143. Mr. Dolomieu cautiously marks this source of delusion. "Easy as it may appear (says he) to distinguish cellular lava, "the observer should be very circumspect, and "examine with attention the local circumstances, before he can decide on the nature "of a porous stone he may meet. External "appearances may deceive; there are rocks "which by their decomposition acquire pores, "though they have no relation to volcanos. I "have seen serpentines partly decayed by exposure to the air, in which round irregular "cavities were formed perfectly resembling the "pores of lavas. Some are capable of forming

" ing the most perfect illusion. I found on " the Pyrenees hornblende so altered by the " vicissitudes of the atmosphere, as to con-" tain as many cells and cavernosities as " certain blocks launched from a volcano." Poncet, 276.

Mr. Dolomieu, it is plain, was well aware that substances found in countries not volcanic, could not owe their origin to volcanos. But unhappily he did not consider that *all* substances found in volcanic countries were not on that account necessarily volcanic. Here lies the source of the numerous deceptions with which his account of the Lipari islands abounds. *Similitude and analogy* to real and acknowledged lavas, or at least *fusibility*, enters as necessarily into the proof of the volcanic origin of any fossil as the mere circumstance of *locality*. It is the union of both that makes the proof complete.

Mr. Faujas, whose testimony on this occasion is above exception, acknowledges that traps and porphyries may assume the appearance of lavas, so completely, as to lead the most experienced observers into error, if local circumstances be not attended to. It is by attention to them that he has shewn that neither the toadstone of Derbyshire, nor the whinstone of Scotland, are really volcanic*.

Dr. Priestley, among his numerous discoveries, seems to have found a decisive character of lavas: he observed that real lavas yield but little air, an ounce not affording above 5,5 ounce measures of air, and sometimes scarce any. Whereas fictitious lavas, as basalts, &c.

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* Sur les Traps, 23, 46, 62.

yield from 20 to 30 ounce measures. 6 Pri. 217.

I have often found real lava to yield hepatic air, basalt never.

Some stones which confessedly have been formed by means of water, have nevertheless had a volcanic origin ascribed to them. They have been deduced from muddy eruptions, of which several are said to have issued from Vesuvius in the last century. Signior Gioeni, however, one of the latest and most judicious observers of that volcano, satisfactorily refutes this opinion. That water should be collected in the focus of an active volcano, is indeed incredible. Some may indeed be formed during the inflammation, but in a quantity too inconsiderable to form a mud. The greater part of that, which has been observed to attend eruptions, proceeds from the reservoirs or caverns filled with water in the body of the mountain. This in the convulsions attending eruptions must often be thrown out, and pour down in torrents.

In the history of the globe we meet with only two accounts of the submersion of the earth under water; the first happened antecedently to the creation of animals, and the second at the time of the general deluge. During the period of the first submersion, submarine volcanos very probably existed, and to them the excavation of the bed of the ocean may be attributed. But these lavas could not involve or cover marine animals, as these did not then exist. During the second period also volçanos might have been in an active state, and marine animals be buried under their ejections. Thus far we are under the guidance of history. But if we proceed farther, and assume alternate stratifications of marine and volcanic productions, we must have either particular historical evidence to rest upon, or undoubted proofs that the substances assumed to be volcanic are really such.

Mountains of Neptunian origin are distinguished by their materials, and often by the arrangement of those materials.

1st, Mountains consisting of granite, gneiss, jasper, argillites, serpentines, limestones, are confessedly of Neptunian origin; so also are those that consist of strata of coal, clay, sandstone, marl, &c. So also are those in which metallic strata, or veins are found.

2nd, The affinity and order that subsists between the different strata often evince a Neptunian origin; thus if we see a hard stone passing by imperceptible degrees into a softer which is not of volcanic origin (or *vice versa*), and this into clay, and the clay into quartz, we may fairly conclude that the first in the series is not volcanic. This mode of enquiry has been invented and successfully pursued by Mr. Werner.

3d, As the Neptunian is by far the most general origin of stones, it may always be presumed, until proofs of a volcanic origin be adduced.

CHAP. IV.

OF STONES TO WHICH A VOLCANIC ORIGIN HAS BEEN IMPROPERLY ASCRIBED.

§ I.—*Of Shorls or Basaltines, and White Garnets.*

It is now generally agreed among volcanic observers, that the shorls found in lavas (more properly called basaltines) pre-existed in the rocks which were the mother stones or basis of lavas before the eruption, and were not formed by subsequent percolation through, and crystallization in, the melted lava. This conclusion is grounded on the following reasons:

1st, Because these shorls or basaltines are found in rocks confessedly not of volcanic origin, for instance in granite *.

2nd, Because the thin fusion requisite for crystallization would convert them into glass, a state to which they do not even approach.

3d, Because the heat requisite for their fusion is superior to that which flowing lava generally possesses, and yet the fusibility of both is exactly the same; if therefore, they were really fused, so also must the lava have been, which yet is not true, as we have already seen.

4th, Because the percolation or infiltration of the particles of which they consist through so viscid a substance as flowing lava, is not easily

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* Helvet. Magaz. p. 156. 1 Sauss p. 67.

sily conceived, that is, is not conformable either to observation, experiment, or analogy.

5th, Because their crystallization in the midst of a dense viscid substance is equally inconceivable.

These reasons are still more strongly applicable to white garnets (Vesuvian) felspars, and olivins, which are still less fusible than basaltines.

Mr. Faujas and Baron Diedrich imagined that shorls exposed to volcanic fires might be distinguished from those found in substances that had never felt their action, by their influence on the magnetic needle. But Mr. Saussure observed the shorls found in the neighbourhood of Geneva, to exert the same influence as those contained in substances confessedly volcanic.

§ II.—*Zeolytes.*

Though zeolytes generally contain from one-eighth to one-fifth of their weight in water, an ample testimony one would think of their Neptunian origin, yet the circumstance of their being found in the vicinity of some volcanos, has induced many to imagine such a connection between them and volcanic operations, that from their existence, at least in certain circumstances, they have thought themselves entitled to conclude, that the rocks in which they are found were subjected in some ancient period to such operations. Some have ascribed their origin to the decomposition of lavas; some to the infiltration of sea-water through lavas; and some imagined them enveloped in lavas in actual fusion.

The following facts, however, subvert all these opinions.

1st, Zeolytes are found in countries where nothing is volcanic, unless the whole earth be deemed so. They are found in copper and gold mines in Sweden. 3 Bergm. 224. They are found between granites in masses of some hundreds weight in Poland. 2 Chym. Ann. 1791, 196. They are found amidst the granites of St. Gothard in Switzerland. Haiding. 52.

2nd, Zeolyte is not found in the lavas either of Ætna or Vesuvius, and, indeed, scarce at all on those mountains; and when found, it is in substances that are not volcanic. Neither Dolomieu nor Gioeni could find any on Vesuvius, nor near it; *Ponces*, 433; and yet, assuredly, it is not deficient in lavas in a state of decomposition. Gioeni, indeed, tells us he discovered *one* specimen of zeolyte on Ætna; not, however, in a lava, but in a marl that enveloped it. He also mentions *one* found in a brown lava, and *one* in another in a state of decomposition*; but as he improperly assumes many substances for lavas which are not really such, we may still doubt, whether, even in the few instances adduced by him, he has not been deceived.

3d, The substances in the neighbourhood of volcanos, in which zeolytes are found, are such as we have reason to judge rather of Neptunian than of volcanic origin. Mr. Dolomieu, after informing us that he never found zeolytes in the modern lavas either of Vesuvius, Ætna, or the Sicilian islands, tells us he has found them in abundance in such of the ancient extinct volcanos of Italy, Sicily, and the adjacent islands, as have been anciently buried under the sea, and are covered with calcareous rocks, and other marine remains. The reality of these volcanos, however, still remains to be proved.

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* Gioeni, 38, 195, 196, 197.

All the zeolytes he mentions in his Catalogue are contained in *what he calls lavas* rendered prismatic, by flowing into the sea; in these he thinks them formed by the gradual filtration of sea-water. Yet the 7th number of his Catalogue, even in his own opinion, is scarcely compatible with this idea; for, the zeolyte contained in this *supposed* lava amounts to half of the whole mass, and appears so necessary a part, as clearly to evince that both were of simultaneous formation*. As the water in zeolytes is not salt, and as no salt is found in the stone through which this water is supposed to have penetrated, the idea of infiltration cannot be supported. These pretended lavas are therefore most probably traps or basalts, which often contain zeolytes, and are not of volcanic origin, as will presently be seen. If this great geologist had recollected his own assertion, that those stony masses on which he bestows the name of *compact lava*, are scarce at all different when ejected out of a volcano from what they were in their natural state; and also that zeolytes must be perceptibly altered even by the most moderate heat; he would rather have concluded that these masses that resemble lava, and yet contain unimpaired zeolytes, were not genuine lavas, but rather primitive stones out of which lavas are formed.

Hence the existence of zeolytes in any mountain or fossil, so far from affording any suspi-

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* Ponces, 347.

sion of their volcanic origin, should rather lead us to conclude that they were never subjected to the operations of the igneous element.

§. III.—*Of Traps and Basalts.*

As the various opinions concerning the origin of basalts form an interesting part of the Mineralogical History of this century, from the numerous researches they occasioned, and the many discoveries both of unknown truths and unsuspected errors that thence resulted, it will not be amiss to state these opinions in the order in which they were offered to the public, before we enter into a particular examination of the merits of each.

The circumstance that first led philosophers into a particular enquiry concerning the origin of basalts, was the discovery of ancient volcanos, now extinct, made by Mr. Guettard, of the Royal Academy of Paris, in the year 1751, and published among the Memoirs of that learned body for the year 1752. These he found in Auvergne; he inferred their ancient volcanic state from the strong resemblance between several fossils they contained and those of Vesuvius; among these fossils, however, he does not reckon basalts; on the contrary, in his Mémoires de Physique, published several years after, he ascribes to them a Neptunian origin.

In 1763, Mr. Desmaretz, a member of the same academy, travelling through Auvergne, observed a multitude of basaltic pillars on the road between Clermont and the celebrated mountain Puyde Dome. These pillars he supposed to be lavas, from the closeness of their texture, their containing a number of shining points, and their having a black or grey colour*; their prismatic form proceeded, as he thought, from their having been in fusion†. This account was published by himself in the Paris Memoirs for 1771; but it was mentioned long before, by Mr. Montet, in those for 1766. About the same time he discovered articulated basaltic columns near the village of Rochefort, and found, by comparing them with those of the Giant's Causeway of the county of Antrim, that they were of the same nature; both he pronounced to be undoubtedly volcanic.

Most of the prismatic masses which he afterwards discovered announce clearly, he tells us, by their situation (at the extremity and borders of currents of melted matter‡), their origin and nature, viz. that of compact lava; yet some, in consequence of subsequent alterations of the primitive disposition of these currents, either by derangement from posterior eruptions, or degradations caused by streams of water, no longer preserve their ancient connection with these currents, and hence are found on insulated summits, whose basis or under strata have been attacked by fire§; often also does it happen that they have no connection with interrupted currents, or even with volcanos; in these cases he supposes them to have been melted where they stand, and their volcanity is, he thinks, established by their colour, grain, and the scoriæ, baked earth, and spongy substances, that constantly accompany them.

Granite, he afterwards tells us, is the mother-stone, by whose fusion basalt is produced*; sensible, however, that he had as yet offered no satisfactory proof that these basaltic pillars were real lavas, and wishing to obviate the strong objections of the celebrated Wallerius, who insisted that lavas were essentially porous, he adds, that he had viewed actual volcanos, and in the torrents of lava issuing from them he had observed the upper part of the bed to be spongy, but that the lower part had always an uniform compact grain like basalt†.

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* Mem. Par. 1771, p. 725, 8vo. † Ibid. 722.

‡ P. 723. § P. 746.

In 1771, Mr. Raspe, in an ingenious treatise on some German mountains, which he supposes to be volcanic, for much the same reason as Mr. Guettard, hazarded a conjecture, that the basalts found in them were lavas that broke their way immediately into the sea, or at least were formed in caverns and holes under its level, at the time that the whole earth was deluged by it.

In 1774, Mr. Monnet, in answer to an objection of Mr. Guettard's, that it was absurd to suppose, that during the agitation and tumult of a volcanic eruption any thing like a regular crystallization could be formed, threw out a suspicion, that basalts were crystallized in the bosom of the volcano in which they were originally fused‡. The same conjecture occurred also to Mr. Gerhard of Berlin, in 1781§.

In 1777, the volcanic hypothesis met with a formidable adversary in the celebrated Bergman, who, after weighing with the greatest impartiality the arguments produced on either side, decided in favour of its production in the moist way. His objections to the volcanic origin will presently be stated.

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* Mem. Par. 1771, p. 751, 8vo. † Ib. 824.
‡ 4 Roz. p. 75.
§ 1 Gesch. 177.

In 1786, the Reverend Mr. Hamilton published his very entertaining Letters concerning the Northern Coast of the county of Antrim, in which, with great ability, yet with some hesitation, he supports the volcanic origin of the Giant's Causeway, and other basaltic columns of that county, and endeavours to prove that they were crystallized by tranquil fusion and slow refrigeration, in the very focus of a volcano. This opinion, though liable, as we shall soon see, to insuperable difficulties, obviates many of those that occurred in former theories, and was, therefore, readily embraced on the continent. Baron Veltheim in particular, who had long before entertained the same notion, published an able defence of it in 1787.

After so much had been published on this subject, the reasons adduced by both parties appeared to balance each other so nearly, that many suspected that basalts and traps might originate in some cases from fire, and in others from water: Ferber, and, finally also, Mr. Gerhard, declared in favour of this double origin. But it found its firmest support in Mr. Dolomieu. His opinion is, that basalts, existing in the neighbourhood of actual volcanos, and (what he supposes) extinct volcanos, were formed by the sudden refrigeration of compact lava, flowing either into the sea, or existing in some other circumstances productive of sudden cooling; hence he thinks that basalt was not crystallized, but owes its prismatic shape to sudden bursting*. In countries, however, in which no volcanic vestiges can be traced, he thinks it, like other stony masses, of Neptunian origin.

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* Notes on Bergm. 57. 37 Roz. 197.

The period, however, at last arrived, at which all volcanic systems, however modified, received a deadly blow. Mr. Werner, of Friburgh, the most eminent and judicious mineralogist that has yet appeared, having casually observed the transition of basalt into wacken, of wacken into clay, and of this clay into mere quartzy sand, substances that were never suspected to have any other than an aqueous origin, by an easy application of the simplest fundamental laws of Mineralogy, inferred that basalt must also have been formed in the same fluid. This important observation (or rather the consequences deduced from it) was afterwards controverted by Mr. Voight, a mineralogist deservedly in high repute, in my opinion, however, with little success*. Observations were henceforward multiplied on most of the German mountains, that had heretofore passed for volcanic, and many were revendicated to Neptune's antique demesne. Of these observations, those of Mr. Reuss on the Bohemian, and of Mr. Nose on the hills contiguous to the Rhine, are worthy of particular attention.

During this controversy, many impartial mineralogists, wishing to see the merits on each side compendiously stated, Mr. Hœpfner, of Viel, in Switzerland, a mineralogist and chemist of distinguished merit, generously offered a premium of 25 rix-dollars to him who should give the most satisfactory answer to the following questions: *What is basalt? Is it volcanic, or is it not?* The premium was adjudged to Mr.

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* 2 Bergm. Jour. 1788, and 1 Bergm. Jour. 1789.

Weideman, a disciple of Mr. Werner's, who combated the volcanic theory; not because the controversy was thought to be irrefragably decided, but on account of the masterly manner in which he handled the subject.

It now remains that I should state the reasons that impress conviction on my mind, that neither basalt nor trap are of volcanic origin. In doing this, I shall at the same time meet the arguments adduced in support of the different modifications of the volcanic theory already stated.

The first circumstance that strikes me very forcibly, and operates equally against all the volcanic theories, is the total absence of every internal mark of fusion. Basalt, I mean the most perfect regularly figured prismatic basalt, is a heavy perfectly compact body, whose fracture discovers a fine splintery or earthy fracture, destitute of all lustre, except that which proceeds from a few dispersed glimmering particles of hornblende crystals. In masses of several feet in length I have not been able to discover the smallest internal cavity, either in that of the Giant's Causeway, nor in that of Stolpe; nor has Mr. Bergman in those he examined*. Now, all fused earthy substances present either a porcelain grain, always glazed if the fusion extended to even one-half of the whole, or conchoidal and glazed if it extended farther, and some air blebs, even if converted into glass; therefore basalt wants the peculiar marks of fusion.

To this plain reason several answers have been given. According to Mr. Hamilton, all the basalts he has seen, exhibit, in one part or other of their substance, air-holes; and it is remarkable (says he), that even the pillars of our Giant's Causeway, which are singularly compact, have their upper joints more or less excavated*; and for this he appeals to a view of those of Dublin college. The gross pillars in the capes and mountains, he tells us, frequently abound in those air-holes, through all their parts, which sometimes contain clay, and other foreign bodies, and the irregular basaltes where the pillars cease, or which lies over them, is, in general, extremely honey-combed, containing in its cells crystals of zeolyte, brown clay, or steatites, &c.

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* 3 Bergm. 211. Van troil, 388. 2 Guettard's Memoirs, 257.

After reading this passage, I carefully examined the pillars in our college, and found, in truth, that in some part, namely, in the top of each pillar, there were two or three minute cavities of the size of the head of a pin, and one-twentieth of an inch, perhaps, in depth, and no more, in the space of twenty square feet. It is plain, therefore, these arose from decomposition, or external accidents; for, if they proceeded from internal air, they would have penetrated much deeper into the body of the stone. This Mr. Dolomieu acknowledges, and gives even as a criterion of stones really volcanic, "I pori esistono nell' interno equalmente inquelle pietre che realmente sono di volcanica origine†." But in the interior of these basalts not the smallest pore appears. Of the opacity, dulness, and texture, of these stones he takes no notice. As to the holes in the irregular basalts, it appears, from his own account, that they proceed from the decomposition of other stones, that were previously contained in them. That many of them contain clay, steatites, or zeolyte, is an evident proof that they are not volcanic; for, the fire that could melt them would evidently harden the steatites, harden or melt the brown clay, and certainly melt the zeolytes, which are not even deprived of their water of crystallization. Mr. Voight, a zealous stickler for the fusion of basalt, answering this objection, contents himself with saying that *many* basalts are found *not entirely destitute of pores**; admitting thereby, that *many*, if not *most*, are free from them; and that those that have any have but few. Now, if any be destitute of them, we cannot hold them for real lavas, and those that have any (since they are all of the same origin) must derive them from some other cause than the expulsion of air by fire.

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* P. 149.

† On 3 Bergm. De Prodotti Volcan. 185

2nd, Mr. Dolomieu answers this objection by allowing it *to be true in every point of view*, and insisting that the igneous origin of basalt can be proved solely by local circumstances. In his Notes on Bergman, p. 59, he tells us, “ It
“ is very true the lavas of prismatic columns,
“ and all other compact lavas, preserve no ap-
“ pearance whatever of fusion, when cold, be-
“ cause lavas are not vitrifactions; volcanic
“ fire does not commonly change either the
“ grain, texture, external appearances, nor the
“ essential qualities of stones, to which it
“ has nevertheless communicated a consider-
“ able degree of liquidity to make them flow
“ in a torrent.” And, in the preface to his account of the Pontian islands, he asserts, “ that
“ volcanic fire does not act like the fires of our
“ furnaces; it produces a liquidity that does

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* Mineralogisch and Bergm. Abhand. 171.

"not resemble vitrifaction; it has no intensity, "and cannot vitrify the most fusible substances, such as shorl. It produces liquidity by a sort of dissolution, by a simple "dilatation, which permits the integrant parts "to slide over each other; and, perhaps, by "the assistance of another matter which is the "instrument of fluidity."

If the action of this fire were really different from that of all fires with which we are acquainted, it would be impossible for us to affirm or deny any thing concerning it; but, before we admit such a mystery, we should be well assured of its existence: in truth, the substance, called *compact lava,* was never really *fused,* but rather *diffused* through liquid bitumen, or bitumen and sulphur, as I have already observed in treating of that substance. But regular basaltic columns, such as are here meant, were neither fused or diffused through any substance liquefied by fire, though in all probability they are one at least of the mother-stones out of which lavas are formed, as Mr. Werner has most ingeniously and happily suggested.

As to the absence of all signs of vitrification, Mr. Hamilton answers, "We are to consider, "that substances in fusion are very differently "affected, in proportion as they are more or "less exposed to the access of fresh air; the "presence of this element being absolutely "necessary, in order to deprive a body of its "phlogiston: thus metals, which may readily "be vitrified by exposure to heat, and the free "afflux of air, will yet bear the most intense "action of fire in close vessels, without being "deprived of that principle. Basalts may have "been therefore subjected to a very great

" degree of heat, and yet shew no marks of
" vitrification; and hence it may be explained
" how it comes to pass, that the iron principle
" of the basalts still retains its phlogiston, act-
" ing so sensibly on the magnetic needle."

In reply to this, little need be said; basalt is not a metal, but a stone, and air has nothing to do with the vitrification of stones; if it had, basalts, whose iron he says is still phlogisticated, could not be vitrified in close vessels; the contrary of which is notorious. I have myself constantly vitrified it in close vessels; so have Mess. Pott, D'Arcet, Gerhard, and others. If the iron in basalt were in its metallic state, it would not unite with the earths at all, but separate from them, as I know by experience; to unite with them, it must be in that semi-calcined state which leaves it at once magnetic, and a medium of vitrification; if it were more calcined it would not promote vitrification, as is well known.

Mr. Voight admits the possible absence of all signs of vitrification, and in so doing admits the absence of all fusion, as the fusion of stones is nothing else than a more or less perfect vitrification. But he objects that many recent lavas of Vesuvius present as few signs of fusion; and yet it must be allowed they were once fluid. Mr. Voight's mistake in this instance is certainly very excusable. He was led into it by the faulty descriptions of almost all the observers of actual volcanos; they almost all mistake the *flowing* of lava, for the *fusion* of lava, though its flowing proceeds almost solely from the liquid bitumen with which it is mixed; as the flowing of mud proceeds from the water, and not from the liquidity or dissolution of the earth it contains. Hence Mr. Dolomieu, the most sagacious, exact, and philosophical, of all of them, allows, in the terms already quoted, that volcanic fire has not sufficient intensity to vitrify even the most fusible substances: this, however, must be admitted with some restriction, as vitreous lavas are sometimes found, though rarely, and scoriæ more abundantly; but where any *real* fusion has taken place the vestiges of it are sufficiently discernible. It has occurred to some, that basalts and compact lavas may have been in real fusion, and yet by cooling slowly all marks of it may have been obliterated, as happens in the fusion of glass, by Mr. Keir's account; but Mr. Keir does not say that all marks of fusion disappeared in his experiment, but barely, that the glass crystallized and became semi-opaque. I have some now by me, that cooled slowly in Mr. Dean's glass-house, part of which is crystallized and semi-opaque, but retains all the sharpness, lustre, and rigidity of glass; but the comparison of stony substances and glass is essentially defective; for, the salts that enter into the composition of glass evaporate in great measure in a strong heat long continued, and leave the other ingredients nearly in their primitive state, and almost as infusible; whereas, in the fusion of most stones in our furnaces, nothing escapes but water and air, and the alteration they thereby receive must for ever remain. Basalts in particular are as fusible as they can be supposed to have ever been.

The second reason that appears to me a demonstration that basalts nor traps were never subjected to the operations of heat is, that they contain substances in a state absolutely incompatible with such operations; for instance, they contain mild calcareous earth, as an essential ingredient in their composition, which must necessarily have been calcined, at least in the superficial parts of those basalts, in a heat much inferior to that which could fuse the basalts. They often contain zeolytes, which must at least have lost their appropriated water; they contain hornblende crystals, which yet are fusible, and consequently destructible in as low a heat as basalt itself; they often contain calcareous spars, which must have been decomposed in the same heat, nay more, neither calcareous spar nor zeolytes are ever found in any modern (that is to say, in any undoubted) lava, as Mr. Dolomieu acknowledges. Ponces, 424.

Neither Mr. Hamilton nor Mr. Voight take any notice of this objection. Mr. Dolomieu endeavours to evade it, by allowing the liquidity of lava not to proceed from fire. With respect to shorls, he expresses himself thus: "It "no longer necessary to refute the opinion of "those who have believed that the shorls of "lavas were products of fire, and that they "were formed either during their fusion or "their cooling; it is too evident that their existence preceded the fusion of lava*;" and again, "It will be still more extraordinary to "find, that shorl, so fusible a substance, has "not received the smallest alteration, has pre"served its angles, its hardness, its internal "texture, and, in general, all its properties. "How has it happened that this single obser"vation has not indicated that the fusion of "lavas has no relation to the vitreous fusions

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* Ponces, 246.

" which we operate in our furnaces? I cannot, therefore, too often repeat, that the " fluidity of lavas is not a vitrification; they " flow, because they are carried off by a substance extremely fusible, which burns at the " same time; and when they congeal, it is less " through the cessation of heat than on account " of the entire combustion and dissipation of " the matter that operated their softness." It is surprising he has not named bitumen, whose operation he so justly describes. But why has not the substance which softened lavas and left them porous, also softened shorls and zeolytes, and rendered them porous?

I shall now proceed to shew the insufficiency of the principal volcanic theories of the formation of basalt, beginning with Desmaretz's as the first, and still the most generally received. This ingenious academician supposes that basalts were formed by the cooling of lava erupted from ancient volcanos; if so, we should naturally expect to find them in the currents of modern volcanos; yet none are found. Mr. Hamilton allows this, and thinks it a strong proof of the truth of his own hypothesis; Mr. Dolomieu assures us, that, of the modern torrents of lava from Ætna, many have been flawed by cooling in the open air, yet they present nothing but irregular masses; many also of the more ancient beds of lava have been laid open, but prisms were never found among them, nor were any found in the caverns of Monte Rosso, nor in the subterraneous galleries of these currents. Ponces, 446, 447. Gioeni, in his catalogue of the minerals of Vesuvius, entirely omits them; and tells us, " the basalts " are certainly of volcanic origin, yet volcanos

" in our days seem to have lost the power of " producing them." Introduction, LIII.

Perhaps I may be told that Sir William Hamilton observed some basaltic pillars near Torre del Græco; but Sir William's own words are, " The lava of Vesuvius that runs into the sea " near Torre del Græco, has an evident tendency to the basaltic form; on Mount Vesuvius I never saw any thing like basalts except that at Torre del Græco, and some fragments thrown up by the eruption of 1779*." Of the latter we shall presently speak, but the former were not basalts, as it seems; for, Gioeni tells us, " I wished to verify the basalts " which I was told were to be found on the " sea-coast near the park of Portici, but I " discovered nothing but a course of compact " lava with very irregular perpendicular fissures, whence resulted quadrangular and " trapezoidal columns. Such fissures are often observed in tufas, and earths of different " kinds, and can impose on no one, habituated " to distinguish their true cause. The only " basalts I found on Vesuvius were those " erupted in 1779, which were collected by Sir " William Hamilton." It is even doubtful whether what he calls compact lava be really such, as most of the volcanic observers have hitherto confounded the mother-stones of lavas with lavas themselves; as to the fragments ejected we shall presently have occasion to mention them again.

This theory having appeared unsatisfactory to many of the volcanists themselves, they next devised that which ascribes the formation of basaltic columns to crystallization in the inside of the volcano, on the very spot on which it was originally fused. Common trap, or, as they call it, imperfect basalt, they still ascribe to effusions of melted matter; in the first case perfect rest, and the most gradual diminution of temperature, have permitted the parts of the melted mass to exert their proper laws of arrangement, so as to assume the form of columnar lava.

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* Phil. Trans. 1786, p. 376.

This hypothesis explains perfectly well why modern volcanos exhibit no basalts; "we must "wait (say its patrons) until they are burnt out, "when the immense vaults which now lie "within their bowels shall fall in; then we may "expect to behold all the varieties of crystal-"lization that take place in these vast labora-"tories of real nature."

But if this hypothesis gets rid of some difficulties, it is pressed by several others that attend it on every side, to say nothing of the general objections already mentioned.

1st, Almost all crystals have a lamellar, some few, perhaps, a striated, or perfectly uniform and vitreous texture, and none whatsoever an earthy fracture. But basalts present an irregular earthy grain, without the smallest tendency to the lamellar.

2nd, All crystals have a smooth, and, at least, one polished surface, or, if not exactly so, one sees at least that the asperity or inequality of their surface proceeds from the fracture of some of the lamellæ, or the adherence of some uncrystalled substance; but basaltic prisms, though they shew an even, yet there is nothing like a smooth or polished surface, or any vestige of fractured lamellæ.

3d, All crystals present either one regular form, or forms, that, one way or other, may be deduced from one regular form, as Abbé Hauy, and Mr. Romé de Lisle, have abundantly proved; but basalts are found of all forms, trigonal, quadrangular, pentagonal, hexagonal, octagonal, &c. as chance directs.

4th, Crystals are formed under some determinate angle, but basalts have none that can be deemed common to them; nay, sometimes they are destitute of all angles, being cylindrical, or oval*.

5th, Basaltic pillars are frequently articulated, a configuration never observed in true crystals.

6th, Mr. Hamilton observes, that basaltic pillars are of a looser and softer texture at the top, but true crystals are homogeneous, and of the same texture throughout: this difference of consistence is very common in uncrystallized stones, as argillites†, and even quartz‡, but never in the crystallized, except when beginning to be decomposed; therefore, basalts differ from crystals in every point of view, except in possessing in common with them a regular polygon figure, a figure often observed in marls and porphyries, whose crystallization was never suspected.

Hence the late excellent crystallographist, Mr. Romé de Lisle, whose willingness to find, and sagacity in tracing, crystalline forms are acknowledged, though he at first admitted basalts among them, yet, in his second edition, on mature consideration, he has excluded them: "these crystalliform masses (says he) are always the products, not of a true crystallization, but of a heterogeneous matter, not dissolved, but precipitated under an irregular form, and afterwards, either by desiccation or cooling, burst or contracted into prisms of a greater or lesser number of sides, but always indeterminate. In vain should one seek in these pretended crystals, either a constant parallelism of the planes, or a determinate measure in the angles, &c." 1 Crystallogr. p. 439.

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* Fauj Mineralog. des Volcans. Chap. IX.

† See Guethard, Mem. Par. 1757, and Lasius, *Hartz*, 102.

‡ Lasius, Ibid. 137.

Besides, it is well known that no substance can crystallize either in a menstruum, or from a solution by heat, unless it be so perfectly dissolved, that its parts have liberty to arrange themselves according to their peculiar attractions; so that, if they crystallize from a state of fusion, the fusion must have been thin and perfect: now it is evident, from such fusion, glass or enamels must be formed, unless the most fusible parts be dissipated or separated; which is not the case in basalts, since in their actual state they are easily and perfectly fusible, so that we have herein a demonstration, *a priori*, that they are not formed by crystallization in the dry way.

Again, basalts are frequently found on the summits of mountains; how then can their formation be confined to internal cavities? Mr. Desmaretz found them on the summits of Puy de Beselles, Puy de Treuil, Puys d'Eragnes, Puy de Mazeires, &c. in Auvergne; Mr. Halck on that of Cottener, near Kœnigstein, in Misnia; Mr. Voight on that of Franenberg; and many others, in the diocese of Fulda; and

Mr. de la Fonds unc multitude de grands pies courronnés par des chaussées de basaltes en prismes. *Volcans Eteints*, 327.

To obviate this objection, recourse has been had to various suppositions grounded on the ancient revolutions of the globe, by which it is imagined these hills were in part destroyed, and only those parts left which support the basaltic pillars; but is not this explaining a *fact* by a possibility? What proof can be adduced, not of a revolution, for that is admitted, but that this revolution has changed the state of these hills? How can this general agent be with any probability applied to this particular case? This is what is required, otherwise a principle is assumed that is the subject of debate; it were strange that such convulsions as should rend mountains should leave the basaltic pillars upright, and standing in their respective sockets, as those do on the coast of Antrim.

Another insuperable difficulty attendant on all the volcanic theories, but particularly this hypothesis, is, that basalts stand on or adjoin substances, which appear not to have suffered in the slightest degree, or to have been at all exposed to heat. How is it possible that such immense masses should have been in a melting heat, for a considerable time, and yet that the adjacent stones, or earths, should not have been at all altered? All this, however, must have happened if basaltes were formed, as the theory which I now consider demands; for, it is found on limestone undecomposed, on gneiss unaltered, on sandstone unmelted, on coal, and even intercepted between strata of coal.

Desmaretz felt this inconsistence, and endeavours to explain it away. "Most of the pris-
"matic

" matic masses (says he) announce clearly, by
" their situation, their origin, and nature of
" compact lava; but some of these masses, in
" consequence of alterations that have visibly
" taken place in the primitive disposition of
" the currents, either in the tumult of posterior eruptions, or more especially by the
" degradations arising from water, have no
" longer preserved their connexion with these
" currents, and in that case we find these pillars single, perched on insulated summits,
" whose basis is a substance no way injured by
" fire." It is surprising, however, that water should sweep away the foundation on which they stood, and yet leave them standing; but even this harsh supposition will not solve the difficulty. Mr. Faujas, near Villeneuve de Berg, found masses of limestone and basalt adjoining to each other, and even incorporated and mixed with each other; he examined the limestone thus mixed, and instead of finding it caustic, as should naturally be expected, it effervesced as usual. In Leske's Cabinet, G. 294, we meet with basalt stuck in granite, and yet the felspar of this granite retains its lustre, and the quartz its transparency.

Dr. Hamilton does not seem willing to allow the fact; he tells us, he found the flints intermixed with basalts, opaque and shivery, and the coal as if it were glazed, and charred, refusing to inflame. As to the flints, it is so common to find them dull, whitish, and opaque, in countries most certainly not volcanic, that this indication cannot be much insisted on. As to the coal, it requires more consideration; in the first place, it is plain it cannot be charred by melted basalt lying on it, for this would prevent the dissipation of the elastic fluids necessary to its charred state. The truth is, that the coal which is often found thus free, or nearly so from bitumen, is the natural carbonite, or carbonic substance, which occurs elsewhere, as well as in basaltic countries; a certain sign that the heat of basalt had not deprived it of its bitumen is, that bituminous wood is frequently found under basaltic masses.

The next hypothesis that occurs to our consideration is that of Mr. Dolomieu. This, it must be owned, escapes most of the objections made to the former theories; it evades those made to the fusion of basalt by allowing it was never really fused; those made to its crystallization, by attributing its prismatic form to sudden cooling, chiefly by flowing into the sea; and those arising from its situation on the summit of hills totally unconnected with any thing volcanic, by allowing that such basalts are not of volcanic origin. 37 Roz. 1790. Hence it is plain Mr. Dolomieu gives up almost every point in dispute, yet he still maintains that the basalts found in the neighbourhood of some few living volcanos, and in those which he supposes to be ancient, and now extinguished volcanos, to have been once rendered liquid by fire, though not *fused* in the manner that earths and stones are in our furnaces. We must, therefore, shew the futility, or the insufficiency of each of these grounds, for attributing to basalts a volcanic origin.

And first, as to the sort of fusion he contends for, unless he means the liquefaction by means of bitumen, it is utterly incomprehensible. This latter is intelligible, but will not answer his purpose; for even this sort of fusion will render substances that undergo it porous, at least in some degree, as we see in genuine compact lava; it will deprive zeolytes of the water of crystallization, and dull the lustre of shorls, for we see the felspars, and white garnets of modern lavas, thus affected.

2nd, The effusion of melted lava into the sea, would not barely split it into prisms, but fritter it to pieces; this I have experienced by pouring melted basalts into water, and throwing a crucible filled with it into cold water.

3d, The circumstance of the vicinity of basaltic prisms in the sea adjoining the actual volcanos of the Sicilian island, either proves nothing, as it does not follow that they are rather the effusions of those volcanos than the mother-stones out of which lavas are formed; or, if we couple it with the above experiment, it rather proves that they are not lavas.

4th, The discovery of basaltic pillars in ancient but now extinct volcanos, is undoubtedly the corner stone of all the volcanic theories, particularly where they seem accompanied with pouzzolana, volcanic ashes, pumice, tufas, &c. However, it never once occurred to the naturalists who made this discovery, that the basalts might be the mother-stones of which lavas were formed, a supposition infinitely more consistent with all their properties and relations than that of their being themselves lavas.

Yet I am far from thinking that all the mountains in which basalts are found, seemingly accompanied as above mentioned, are in reality volcanic; few of those who have observed them have given any proof that the substances on which they bestowed the name of porous lava, pouzzolana, volcanic ashes, &c. were that in reality which their names import. Mr. Whitehurst, and others, have bestowed the name of lava on the toadstone of Derbyshire, the rowley ragg, and whinstones; yet Mr. Ferber, and Faujas de St. Fonds, both sufficiently expert in detecting lavas, deny these stones to be really volcanic; and Dr. Priestley found their aërial contents very different from those of genuine lavas.

The stone called wacken has often been taken for indurated volcanic ashes; decayed traps, and porphyries, for pouzzolana. Real pumice is indeed volcanic; but it is often found at great distances from the places that gave it birth; hollows formed on the tops of hills by water, or by shepherds for shelter, have been taken for the mouths of volcanos, from which streams of lava have issued sufficient to cover countries some hundred miles in circumference, though these were often but a few feet in diameter; where no such hollows were found (and this is the most common case), they are supposed to have been destroyed by some subsequent revolution; where the pretended lavas alternate with marine *exuviæ,* this is attributed to successive alternating revolutions. The sublimity and marvellousness of these stupendous operations, supersede the necessity of proving them; yet, even in works professedly designed to excite these emotions, it is a rule, *nec Deus intersit nisi dignus vindice nodus,* much less should these revolutionary principles be admitted in natural philosophy; regularity and uniformity being the great character of the operations of nature, unless their vestiges be fully and incontestibly established.

Let it not be thought presumptuous, in those who have not seen living volcanos; to contest the volcanic character of fossils with those who have long and often contemplated those great phenomena; for the most ingenuous of those who have beheld these eruptions, acknowledge that very little is to be learned from them. Collini, who twice ascended Vesuvius, and witnessed its eruptions, complained that he was thereby no way forwarded in volcanic knowledge. Strange affirms that the view of extinct volcanos is much more instructive. "The "phenomena of recent volcanos (says he) are "very little calculated to give us much in"struction. A few days tour in such coun"tries as Auvergne, Velais, and the Venetian "state, are worth a seven years apprenticeship "at the foot of Vesuvius or Ætna. In effect, lavas, pouzzolana, tufas, &c. may as well be examined at a distance as in the neighbourhood of volcanos, and are generally brought to distant countries as objects of curiosity; but amygdaloids, and decayed porphyries, and wackens, which bear a strong resemblance to volcanic products, are not much attended to, nor commonly known by volcanic observers, and hence when they quit real volcanic countries, and meet these, they mistake them for those products to which their eyes were accustomed; and form theories possibly very sublime, but perfectly romantic.

Sir William Hamilton discovered a few fragments of basaltic columns, ejected by Mount Vesuvius during the eruption of 1779. This Baron Veltheim deems a strong proof of his theory; namely, that basalts are formed by crystallization in the bottom of volcanos; to me, however, it seems a decisive proof of Mr.

Werner's opinion, that basalts and traps are the mother-stones (though not solely) of lavas; for, in the first place, it is plain these columns were not formed by sudden refrigeration, as Mr. Dolomieu pretends; and, in the next place, it is evident that this volcano being as yet in its vigour (for it had not cooled since 1777), the ejected basalt could not have been formed by crystallization on cooling; nor can it be supposed to have been formed in any ancient period, as the lavas anciently formed must have been long before disgorged in the many eruptions that took place since 1631. The most probable account, therefore, that can be given of it is, that, as the volcanic fire yearly scoops out the mountain to greater depths, it at last descended to Neptunian stones, which until then remained untouched; what adds great probability to this conjecture is, that Gioeni expressly remarks that part of it was untouched by fire. Lithol. Vesuvian. LIX.

It has been observed, that bricks and earthenware emit a clear sound when struck, and, as basalt has also this property, some have thought this a proof of its having had a volcanic origin, not recollecting that common roof-slates possess this property, and many limestones, as Mr. Saussure observed, and particularly those of the mountain of St. Barbe, in Provence; 35 Roz. Jour. p. 31; and even stalactites. Lasius, *Hartz*, 198.

The magnetism of some basalts appears to some a proof of volcanity; but all basalts are not magnetic. Baron Veltheim tells us he scarcely met one in a thousand that was so; but, if they all were, this property would not decide their origin, for many stones are magnetic which no one pretends to be volcanic. For instance, garnets, hornblendes, the shorls, found near Geneva, and the metalliferous stone of Born. 1 Bergm. Jour. 1789, p. 607.

There is another system which attributes not only to basalts, but to all stony substances, an igneous origin; it is that of Lazaro Moro, revived, and wonderfully improved, by Dr. Hutton, of Edinburgh, well known by his excellent Essay on the Origin of Rain. This may be called the *Plutonic* system. I have endeavoured to shew its fallacy in a paper lately read to the Royal Irish Academy, which will appear in the next volume of its Transactions.

All that has been hitherto said, tends to disprove the igneous origin of basaltes, and consequently to evince its production in the moist way, as there is no medium between the one and the other; I shall now, however, state a few reasons that point directly to a Neptunian origin.

1st, It is well known, to those who occupy themselves with mineralogical researches, that in stones composed of three or four ingredients, transitions or gradations are frequently observed, from the more simple to the more compound, or *vice versa*, or from one species of stone to another that bears it a kindred relation; so that, if any of the terms of the transition be of volcanic origin, the whole graduating series must be of the same origin; and, if any of the terms be decidedly Neptunian, the whole series must be Neptunian. This ingenious and convincing mode of investigation was discovered, and, in this case, happily applied, by Mr. Werner, on the mountains of Scheibenberg. Here gneiss forms the lowest stratum or basis of the hill. On this a quartzy sand immediately reposes,

poses, which is indisputably of Neptunian origin, if any stone be so; immediately over this sand there lies a stratum of clay, much blended with sand; above that the clay is less sandy; above that it becomes harder; still higher it is found mixed with wacken; still higher the wacken becomes harder; and still higher it passes into basalt. Who does not see that this whole graduating series of fossils must have had a common origin, and all to have been formed in the same fluid? and let it be considered, that wacken must have been formed in the moist way; for, in fire it becomes remarkably cellular. Besides, branches, leaves, and roots of trees, have frequently been found in it. In various other instances, basalt or trap has been found to pass into argillites and sandstones, both, confessedly, of Neptunian origin.

2nd, Dr. Beddoes, in the Philosophical Transactions for 1791, has shewn, (though with a very different intention) an evident connection between basalt, trap, and granite. They lie, as he observes, "so contiguous, and often so involved in each other, that one cannot but "suppose both to have undergone the same "operations of nature at the same time." A concretion of this sort extorted from Ferber an avowal that basalt might be produced in the moist way. *Italy*, 16 Letter.

3d, Some irregular basaltic pillars were lately discovered in Bohemia, containing indurated marl, with the impression of a vegetable resembling cerastium, or alpine. 1 Chy. Ann. 1792, p. 70. The consequence is obvious. The great stumbling-block in the way of this theory, and, indeed, of every other, is the difficulty of accounting for the regular formation of the prisms. It, however, is much easier accounted for in this system than in the volcanic, as we can produce many instances of similar prisms in fossils *undoubtedly* formed in the moist way, and none at all of any *undoubtedly* formed in the dry. This form seems to me to proceed from the sudden bursting of basaltic masses, whether from drying, or the absorption of air, I shall not decide. This opinion is founded on the following reasons:

1st, In a heap of stones of the species called in Dublin, *black quarry-stone*, extracted from a quarry near Palmerstown, and described in my Elements of Mineralogy under the name of *calp*, Mr. Gandon, the celebrated architect of most of our public edifices, discovered one lying under several others in the area of the custom-house, which had burst since it was brought there, into regular pillars, some of an hexagonal, and some of an octagonal form, and some articulated exactly like the pillars of the Giant's Causeway. These pillars were at first about six inches long, and one-fourth of an inch in diameter, but afterwards accidentally broken when removed to his apartment; in this state I have seen them. One of our commissioners of the revenue saw them before their removal. This stone resembles basalt somewhat in its composition, but contains a much larger proportion of calcareous earth, and a much smaller of iron,

2nd, Mr. Dolomieu, in the province of Vòlaterra, found micaceous marls to assume a prismatic form on drying. Near Cape del Bove he found tufas split into regular hexagonal pillars, six or seven feet long. Mr. Strange discovered granitic pillars in the Euganeon mountains, undoubtedly formed in the same manner. Columnar porphyries have several times been observed. We should therefore no longer wonder at seeing basaltic pillars formed by the same accidents.

THIRD APPENDIX.

Of the Chemical Analysis of Earths and Stones.

THIS subject, treated in its full extent, would require a particular account of the manner of analyzing not only each particular genus, but also most of the various species contained under those genera; it is easy to see this would require an immense detail; my intention, therefore, is to consider these fossils abstractedly from all external characters, and solely in their relation to chemical agents, particularly to spirit of nitre, and the vitriolic acid.

In this point of view they may be divided into seven classes:

1st, Those that are wholly or partially soluble, and with effervescence, in nitrous acid, whose specific gravity is 1,4, or higher.

2nd, Those that are insoluble in nitrous acid 1,4, but wholly or partially soluble, and with effervescence, in nitrous acid 1,25, in the temperature of 60°.

3d, Those that are insoluble in spirit of nitre or nitrous acid 1,25, but totally or partially soluble, and with effervescence, in spirit of nitre 1,10.

4th, Those that are soluble in spirit of nitre, in the temperature of the atmosphere, but without effervescence.

5th, Those that are soluble in the nitrous acid, without effervescence, but only in the temperature of from 150° to 180°, or higher.

6th, Those that do not effervesce with the nitrous, but effervesce slightly with the concentrated vitriolic acid.

7th, Those that are insoluble both in the nitrous and vitriolic acid, or only very slightly soluble, and with little or no effervescence, without particular management.

Before earths or stones are subjected to this test they should be reduced to powder. Earths in particular should be boiled in sixteen times their weight of water, to discover their saline contents; distilled to discover their volatile ingredients, and gradually heated to redness in a covered, and afterwards to whiteness in an open crucible for half an hour, to observe their change of colour and loss of weight; both, as circumstances indicate, may be projected on melted nitre heated to redness, to discover whether they contain the carbonaceous principle.

In the present state of mineralogical knowledge, analysis is become an object of complicated attention, as notice must be taken of the nine earths already enumerated;—five acids, namely, the vitriolic, marine, sparry, phosphoric, and boracic;—five metallic substances, iron, manganese, nickel, cobalt, and copper.—Not that all these are ever found in any compound, but, it being uncertain which of them may occur, none of them can be overlooked in general analytic formulas.

The combinations of the tungstenic acid I refer to the fourth part of this treatise.

Before any analysis is attempted, the following substances should be procured in sufficient quantity, and in the greatest purity: concentrated vitriolic acid of the specific gravity of 1,8, spirit of nitre 1,400. 1,250. 1,110. spirit of salt 1,12, distilled vinegar, pure vegetable alkali, crystallized soda. Prussian alkali, caustic and mild volatile alkalis, common lime-water, stronthian lime-water, barytic lime-water, acetated and nitrated barytes, solutions of nitrated calx, nitrated mercury and nitrated silver, sugar of lead, purified chalk, and spirit of wine, with plenty of distilled water.

Of Stones and Earths easily soluble, not less than 400 grains, should be employed; but, of the difficultly soluble, 200 may be sufficient.—Filtres formed of unsized paper, and of different dimensions, should be had, dried in the temperature of 80°, greased at the edges with melted tallow, and weighed; their weight after burning should also be known and noted.

The mouths of the larger vessels should be surrounded with wax, and a waxen spout contrived in the part out of which the liquors are to be poured.

Silver crucibles should be employed whenever the heat required will permit their use.

Other circumstances, commonly known, I omit.

Every step of the process should be registered as soon as taken.

§ I.—*Of*

§ I.—*Of Stones or Earths wholly or partially soluble, and with Effervescence in Spirit of Nitre, whose Specific Gravity is 1,4 or higher.*

1. Stones which, when pulverized, are soon and entirely soluble in a heat below 80°, and with effervescence in spirit of nitre, whose specific gravity is 1,4, at the temperature of 60°, and whose solution is colourless, are either entirely calcareous, or consist partly of calcareous, and partly of muriatic earths combined with fixed air.

2. However, there are scarce any stones but the purest calcareous spars that are so circumstanced; most other stones of the calcareous genus have some sediment undissolved, or afford a somewhat turbid solution, or are slightly discoloured.

3. The insoluble residuum may consist of mild barytes or stronthian, or of either or both of these combined with the vitriolic, or, perhaps, other acids, or of calcareous earth combined with the vitriolic acid; but most commonly it consists of argill, or argill and some sand of the siliceous kind, commonly blended also with calx of iron.

Examination of the Solution.—4. The stone or earth cleared from all foreign visible ingredients, and dried as already mentioned, if an earth, and hardened by that heat, it should again be pulverized, weighed, and put into a portion of the acid, also weighed in a balanced flask, that the weight of air lost may be found in the usual manner.

5. After a few hours the solution should be

diluted with distilled water, shaken, thrown on a filtre, and the residuum washed until the water comes off tasteless, or gives no precipitate with a mild alkali; this residuum, when dried, should be added to No. 3.

6. The solution should then be gently evaporated to a moderate quantity, and treated with caustic volatile alkali as long as any precipitation appears; this will precipitate the argill and calx of iron, and part of the magnesia, and also phosphoric selenite, if these substances exist in it. The precipitate should be well washed on the filtre, and the washings added to the solution.

7. The solution thus cleared can consist only of lime and some magnesia; to separate these, add the vitriolic acid as long as any precipitation appears, evaporate the liquor to nearly its original bulk, No. 4, or farther, and throw the whole on a filtre, wash the precipitate with dilute spirit of wine, and add the washings to the solution.

8. The solution can now contain nothing but magnesia, and some portion of selenite; evaporate it considerably, the selenite will fall; throw this also on the filtre, and edulcorate as before.

9. Evaporate the remainder of the solution to dryness, and re-dissolve it in pure water, adding more acid; if necessary, precipitate the whole by a mild fixed alkali; dry the precipitate first gently, and then in a heat nearly red; its weight is that of the mild magnesia in the solution.

10. Next proceed to the selenite; this should first be gently dried, then heated to redness, and weighed; 100 grains in that dry state

contain about 37 grains of lime; but the best method of finding its true contents is to decompose by boiling it with 1,5 its weight of crystallized soda, the boiled liquor will leave on the filtre the mild calx, which, washed, dried, and heated to redness for half an hour, should be weighed; its proportion of lime is generally as 9 to 5.

Examination of the Precipitate, No. 6.—11. This may consist, as we have said, of argill, calx of iron, some portion of magnesia, phosphorated calx, and, perhaps, some siliceous substance which often passes the filtres.

12. Let the precipitate be well dried, heated nearly to redness, pulverized, weighed, and heated with four times its weight of pure nitrous acid.

13. If it contains phosphorated calx, this will be slowly dissolved in the common temperature of the atmosphere, and scarce any thing else will be taken up.

14. To determine this, drop a little vitriolic acid into the solution; if it contains phosphorated calx, a precipitate will appear.

15. As a small proportion of gypsum may also exist in the solution, to determine this doubt, let a few drops of nitrated barytes fall into the solution; if a precipitation arises in this case, and none in the former trial, it must be from some vitriolic salt in the solution.

16. If a precipitation takes place in both trials, it may be doubted whether it proceeds in this last trial from the phosphoric acid singly, or from the presence of the vitriolic salt; the doubt may be decided by examining the precipitate.

17. But if in neither case a precipitate appears, we may be assured that in the precipitate, No. 6, neither gypsum nor phosphorated calx exist.

18. In case either or both these acids be found, we shall see in No. 37 and 67, how they and their bases are separated and determined.

19. Supposing then the four parts nitrous acid to be inactive, or nearly so, without the assistance of heat, let the whole be strongly and repeatedly digested until the greater part is dissolved; let the acid then be distilled off to dryness twice, pulverizing the dried mass each time, before any new affusion of acid; and at last heated to redness in the retort for half an hour, after which the dried mass is to be gently digested in dilute nitrous acid, which will take up the argill and magnesia, leaving the calx of iron highly oxygenated: let the whole be thrown on a filtre and washed.

20. The filtred liquor should then be precipitated by mild fixed alkali, and the whole boiled to expel the loose fixed air, that may keep the earth in solution.

21. This precipitate should then be thrown on a filtre, washed, dried, heated to redness, and weighed.

22. Then pulverized again, treated for a few hours with eight or ten times its weight of distilled vinegar without heat, to take up the magnesia, if any, and filtred.

23. The acetous solution should then be treated with a mild fixed alkali, it will precipitate the magnesia, which is then to be filtred, washed, dried, heated nearly to redness, and weighed.

24. If any argill be suspected to be con-

tained in it, the vitriolic acid by its slow solution of it will detect it.

25. Argill and magnesia may also be separated by boiling the whole in dilute vitriolic acid, and saturating the acid exactly by mild calx, which will precipitate the argill, but not the magnesia; and as the selenite also falls to the bottom on cooling, the magnesia will remain in solution, and be discovered by the taste.

26. If the quantity of argill be but small, relatively to that of magnesia; it may most conveniently be separated by boiling the whole in pure caustic fixed alkali, which will take up the argill, and leave the magnesia.

27. The dissolved Epsom salt, No. 25, will be made to deposite the selenite it may still contain by gradual evaporation.

28. The residuum on the filtre, No. 22, may be supposed to be pure argill, if it be perfectly white; if not, it should again be dissolved in nitrous acid, which will leave the iron, if any, undissolved.

29. To remove all doubt of the nature of the argill, it may be essayed with boiling caustic fixed alkali, which dissolves argill, but not jargonia.

30. The calx of iron, No. 19, should then be roasted with a little wax for a quarter of an hour in a red heat, it will thereby be so far reduced as to be magnetic, and contain about 70 per cent. of metallic iron.

In many cases where metallic substances are fully disengaged, and the solution coloured by them, they may be precipitated by the Prussian alkali, as will be seen No. 95.

Examination of the Undissolved Residuum, No. 3.—31. This residuum washed, dried, heated to redness, and weighed, is first to be essayed for stronthian, by treating it with spirit of nitre 1,4, diluted with its own weight of water; whatever dissolves in this acid with effervescence, without the assistance of heat, is mild stronthian; the solution should then be diluted and filtred, and the deposite on filtre washed, dried, and added to the remainder of the undissolved residuum.

32. The filtred liquor should then be gently evaporated, and set to crystallize, and the crystals redissolved in about their own weight of water, in the temperature of 66°, as crystallization, and solution in this quantity of water, of that temperature, are additional proofs of stronthian; the solution of the crystals should then be precipitated by mild soda, the precipitate washed, dried, ignited for half an hour, and weighed.

33. After essaying the residuum, No. 3, for stronthian; whether it be found or not, let it be essayed for barytes, by spirit of nitre 1,4 diluted with four or five times its weight of water; if an effervescence then arises, and not before, we may be assured the residuum contains mild barytes, which is to be extracted, as shewn No. 32; the barytic solution should crystallize, but the crystals require many times their weight of water, to dissolve them; a circumstance which distinguishes them from those of stronthian.

34. The residuum should next be essayed for argill by repeated digestion in strong nitrous acid, abstracting that acid by distillation to dryness, as in No. 19, and dissolving the residuum in dilute nitrous acid; thus the adhering calx of iron may be separated as there shewn.

35. The substances undissolved, after these essays, may be either gypsum, baroselenite, siliceous sand, or calx of iron; to separate these let this residuum be washed, dried, and mixed with two and a half times its weight of aërated soda deprived of its water of crystallization; and the mixture roasted for an hour or more, in the lowest red heat, in a crucible covered by another, then sufficiently washed on a filtre, and dried.

36. The filtred liquor should with the washings be somewhat evaporated, saturated with marine acid, while any effervescence arises, then farther evaporated, and filtred; a siliceous substance is often thus detected, which should be dried, heated to redness, and weighed; argill is also often thus had.

37. The remainder of the filtred alkaline liquor should then be diluted, and essayed for vitriolic acid by nitrated or muriated barytes, the baroselenite precipitated, washed, dried, ignited, and weighed, will determine the quantity of vitriolic acid in the solution, as baroselenite thus made contains one-third of its weight of vitriolic acid, of the same strength as that in tartar vitriolate.

38. We now recur to the dried deposite, No. 35; this should be treated with nitrous acid, which will take up the barytic and calcareous earths, if any, and possibly some portions of argill and iron, from which the solution should be freed by caustic volatile alkali, and filtration; these are to be separated from each other, as in No. 34.

39. The filtred liquor now contains nothing but calx and barytes.

40. These may be separated by precipitation,

by the vitriolic acid which will form a mass of baroselenite and gypsum; hot water will gradually take up the gypsum, but leave the baroselenite; the water gives up the gypsum, by evaporation to dryness; the dry mass should be heated to redness, weighed, and treated as in No. 10, and the baroselenite as in No. 37.

41. After these separations nothing but the calx of iron and silex can remain; the calx of iron should be taken up by marine acid, or by aqua regia, and, being filtred, the silex will remain on the filtre, which, when dried, should be heated to redness, and weighed. The martial solution should be precipitated by caustic volatile alkali, which should be treated as in Nos. 19, and 30.

42. If the fluor or boracic acids be suspected in these stones, how the former may be detected will be shewn in No. 72, and the latter in No. 81.

43. If the marine acid exists in them, it will be found in the solution No. 4, and may be precipitated by the solution of nitrated silver, of which 235 grains contain, when heated below redness, as much marine acid as 100 grains of common salt.

44. 100 parts luna cornua, dried in the temperature of 212°, contains 16 grains of marine acid, and 9 of water.

§ II.—45. *Of Stones insoluble in Spirit of Nitre 1,4; but wholly or partially soluble, and with Effervescence, in Spirit of Nitre 1,25, in the temperature of 60°.*

46. These stones are of the stronthian genus, but may contain a mixture of barytes, baroselenite,

roselenite, gypsum, argill, calx of iron, and silex.

47. How stronthian, barytes, and argill should be separated, may be seen from No. 31, to No. 35.

48. How gypsum, baroselenite, calces of iron, and silex, may be distinguished and separated, has been shewn from No. 35 to 41 inclusively.

49. The nitrous acid 1,25, may, along with the stronthian, dissolve a portion of gypsum; this, however, cannot stand in the solution along with the stronthian, as it would immediately be decomposed and a vitriolated stronthian formed; this would precipitate, and should be decomposed by calcination with mild soda, as in No. 35, the alkaline part washed off, and treated for vitriolic acid, silex and argill, as in Nos. 36 and 37.

50. The deposite on the filtre from the alkaline solution may then consist of mild stronthian, barytes, and calx, as also of argill, silex, and calx of iron.

51. To separate them, the whole or all that is easily soluble, should be dissolved by digestion in nitrous acid; the digestion need not be obstinate, as only the argill, silex, and calx of iron, can make any considerable resistance, and they may afterwards be treated apart, as in Nos. 34 and 41.

52. The barytic stronthian and calcareous earths being held in solution together, perhaps with some portions of argill and calx of iron, the two last should be got rid of by precipitation with caustic volatile alkali, and afterwards separated from each other by the means already often mentioned.

53. The solution is now supposed to contain only the three first earths; to ascertain this point, it should first be well boiled, to expel the fixed air that might have been absorbed, and then a small portion of it essayed with stronthian lime-water; if this produces a precipitate we may be assured that calx exists in the solution, otherwise not.

54. If stronthian lime-water produces no precipitation, we should essay another portion of the solution with barytic lime-water; if this produces a precipitate (stronthian lime-water producing none), we may infer that stronthian exists in the solution, and not calx; but, if barytic lime-water produces none, we may conclude that barytes only exists in the solution; if both stronthian lime-water and barytic lime-water occasion precipitates, it remains dubious whether the three earths are contained in the solution, as this appearance would take place if calcareous earth alone existed in it.

55. This doubt, however, may be resolved by evaporating the solution in a moderate degree, and suffering it to cool; for, first, the nitrated barytes, and then the nitrated stronthian, would crystallize; the nitrated calx not. The nitrated stronthian is soluble in once or twice its weight of water; the nitrated barytes requires much more.

56. Or still better, by precipitating the whole with vitriolic acid, filtering and evaporating the remainder nearly to dryness, to obtain the whole of the selenite, if there be any, the deposite on the filtre will then be freed from selenite by repeated affusions of hot water, and the solution, by evaporation, will deposite it, adding spirit of wine towards the end.

57. This being done, the precipitate on the filtre can now consist only of vitriolated stronthian and barytes; to separate these, the dried mass must be heated with two and a half times its weight of depthlegmated aërated soda, to redness, for an hour or more, in a silver crucible, and then the alkaline matter washed off on a filtre.

58. The deposite on the filtre, ignited and weighed, should then be treated with nitrous acid, which will hold both the stronthian and barytic earths dissolved; the solution, having been boiled for some time, may be heated with barytic lime-water, which will precipitate the stronthian, if any exists in it, if not, it is wholly barytic.

59. If stronthian exists in it, it will be left on the filtre in the state of lime, which should again be re-dissolved in nitrous acid, and precipitated by mild volatile alkali; this, washed, dried, heated, and weighed, gives the quantity of mild stronthian, which, subtracted from that of the mixed deposite, No. 58, gives that of the mild barytes. It is probable also, that nitrated barytes and stronthian may be separated by crystallization, as the barytic part may be presumed to crystallize long before the nitrated stronthian.

§ III.—60. *Of Stones insoluble in Nitrous Acid,* 1,2, *but totally or partially soluble in Spirit of Nitre, whose specific gravity is* 1,10; *and with Effervescence.*

61. These stones consist of mild barytes, with, perhaps, a mixture of gypsum, baroselenite, argill, silex, and calx of iron; the bary-

tic part being dissolved, how the others should be separated has been shewn from No. 35 to 41 inclusively.

§ IV.—62. *Of Stones soluble in Nitrous Acid, with none, or scarce any, Effervescence, in the temperature of the Atmosphere.*

63. Of this sort I know none but phosphorated calx *; and, as it may contain some portions of aërated calx, to detect this, the portion of the stone to be analysed should be weighed, and dissolved in five times its weight of nitrous acid, and the loss of weight, if any, indicating the aërated state of the stone, should be noted, the solution filtred, the residuum on the filtre washed, and the washings added to the solution.

64. The filtred solution should then be treated with caustic volatile alkali, which will precipitate the phosphorated calx, and leave that proportion of calx which was simply aërated in the solution; the phosphorated calx should then be separated by filtration, washed, dried, and heated.

65. The solution, now containing the aërated calx singly, should be heated with mild volatile alkali, which will precipitate the calx in an aërated state, to be afterwards washed, dried, and heated to redness for half an hour, and then weighed; the quantity of calx will be to the whole of the aërated calx as 5 to 9. If magnesia be suspected, the solution may be treated with vitriolic acid, as shewn from No. 7 to 10 inclusively.

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* Dolomias effervesce more considerably and durably.

66. We now return to the phosphorated calx, No. 64; this should be dissolved in four times its weight of nitrous acid; after solution, the vitriolic acid should be added as long as any precipitate appears, the whole should then be filtred, and the selenite on the filtre washed with dilute spirit of wine; the filtred liquor should then be considerably evaporated, to make it deposit the whole of the selenite; spirit of wine may also be added to promote its separation, and the whole afterwards caught on a filtre.

67. The selenite being thus expelled, the liquor should again be slightly diluted, and kept in a boiling heat, to expel the nitrous acid; the phosphoric will soon after thicken, and often grow purplish from manganese contained in it; the glass containing it should then be taken up and weighed; that this acid is the phosphoric, may be evinced from its copious precipitation of lime-water, by its giving white precipitates with the solutions of vitriol of iron, and nitrated mercury, and its inability to precipitate the solutions of nitrated or muriated barytes.

68. The selenite is next to be decomposed by boiling it with mild soda, as in No. 10.

69. The deposite on the filtre, No. 63, if any be, should next be examined; it may contain gypsum, baroselenite, argill, silex, and calces of iron, the separation has been already shewn, from No. 35 to 41.

Phospholite should also be distilled with its own weight of strong vitriolic acid, to discover whether it contains the fluor acid, as it often does; the sparry acid air may be known by its absorption by moist charcoal, on which it deposites a siliceous crust. It may also be essayed for marine acid by boiling it in water, and examining the water by the solution of silver.

§ V.—70. *Of Stones that effervesce slightly with the Concentrated Vitriolic, but not with the Nitrous Acid.*

71. The only stones of this sort I am acquainted with, are the fluors which consist of calx and fluor acid, with some mixture of silex and iron.

72. To analyse these or any other stone suspected to contain the fluor acid, let one part of the pulverized stone be well mixed with two parts of dried mild soda, and the mixture melted in a silver crucible; let the melted mass pulverized, be thrown into warm water, and digested in a boiling heat in a pewter vessel, and then filtred; the earthy part will remain on the filtre, and should be washed, dried, and heated to redness.

73. The solution then containing the alkali united to the sparry acid should be slightly evaporated, and the unsaturated part of the alkali neutralized by distilled vinegar (as this will not expel the sparry acid), and then boiled to expel the fixed air absorbed during the saturation with the acetous acid.

74. The solution of fluorated soda, being thus prepared, dissolve a known portion of acetated lead in a known weight of pure water (to which a little distilled vinegar should be added, to prevent precipitation), and gradually drop the solution into that of fluorated soda; the fluor acid will unite to the lead, and imme-

diately precipitate; separate this precipitate by filtration, wash, dry, and heat it to 400°, and then weigh it; its weight, minus that of the lead and of the silex that may be mixed with it, gives that of the sparry acid contained in the stone.

75. To find the weight of the lead and silex, two processes are necessary:

First, Mix the fluorated lead well pulverized with about its own weight of charcoal, place the mixture in a covered crucible, and heat it to whiteness for a quarter of an hour; weigh the reduced lead.

Second, Take a quantity of acetated lead equal (or double, or treble, &c.) to that employed in precipitating the sparry acid, reduce it by fusion with charcoal as before, and find its weight.

76. If the weight of the lead found by the second process be just equal (or double or treble, if such quantities were used) to that found in the first process, then the fluorated lead, No. 74, contained nothing but lead and sparry acid; but if the lead in the second process exceeds the proportions just mentioned, the excess denotes the weight of the silex mixed with the fluorated lead; if it fall short, the operations were ill conducted, and should be repeated.

77. Another method of finding the quantity of lead in the fluorated lead may also be employed; let a quantity of acetated lead, equal to that used in precipitating the sparry acid, be dissolved in water, and to this solution add as much vitriolic acid as is necessary to precipitate the lead, then evaporate the whole to dryness, and heat the dry mass to redness for near a quarter

ter of an hour, its quantity of lead will be seven-tenths of the whole weight.

78. The deposite on the filtre, No. 72, should next be examined, and essayed for phosphoric acid, as shewn in No. 66; and also by volatile alkali, and the silex and calces of iron separated, as in No. 41.

§ VI.—79. *Of Stones soluble without Effervescence in the Nitrous Acid, but whose Solution requires a heat of from* 180° *to* 212°.

80. Stones compounded of argill and unaërated calx, or magnesia, or either or both of these earths, combined with the boracic acid, are comprehended under this head.

81. To discover and separate this acid, these stones, heated, pulverized, and weighed, should be digested in the nitrous acid, to which concentrated vitriolic acid, one quarter of the weight of the stone, should afterwards be added, and the whole gently evaporated, nearly to dryness, in a glass retort; during the exsiccation part of the boracic acid will sublime; spirit of wine added to the dry mass, while still hot, repeatedly, will dissolve the remainder; when the spirit of wine takes up no more, (which will be known by evaporating it to dryness), water should be added to detach the mass from the retort, and the whole thrown on a filtre, washed, dried, and mixed with 2,5 its weight of dried mild soda, and heated to redness for one or two hours, then thrown on a filtre, and washed.

82. The filtred liquor, saturated with an acid, and boiled to expel the fixed air, and

gradually evaporated, will deposit the siliceous and possibly the argillaceous matter it may contain.

83. The washed mass, No. 81, should then be dried, dissolved in nitrous acid, and heated with caustic volatile alkali, to precipitate the argill and part of the magnesia it may contain; and then proceed, as shewn from No. 6 to 30.

§ VII.—84. *Of Stones insoluble in Acids, without particular Management, or, at least, scarcely soluble, and with little or no Effervescence. Of this sort are most of the Stones of the Muriatic, Argillaceous, and Siliceous Genera, and also Gypsum and Baroselenite.*

85. All these, even the softer, are much more easily decomposed when their parts are disintegrated by torrefaction, in a low red heat, with twice, or twice and a half, their weight of dried mild soda, avoiding fusion, but the hardest, as the precious stones may be even melted with six or eight times their weight of caustic fixed alkali, and one or other of these operations should be repeated until the siliceous part of the stone, after digestion in aqua regia, and subsequent torrefaction, becomes white, and perfectly vitrifies with its own weight of fixed alkali, with effervescence, or absolutely refuses to do so, and thus appears to be adamantine.

86. The torrefied, or melted mass, if whitish, contains but little of any metal; if bluish, probably manganese; if greenish, manganese and iron; it should then be well pulverized, thrown

on a filtre, and treated with pure water, until the water comes off tasteless. Many saturate the alkalized mass immediately with nitrous or marine acid, instead of water; and often this is advantageous and proper, as all the soluble earths are then in a greater state of division, and consequently more easily soluble; but it may also happen, that the stone contains the vitriolic acid, which, during torrefaction, with the alkali, unites with this alkali, and also calx, or barytes, or magnesia; when the whole is afterwards dissolved in the nitrous or marine acids, a double decomposition in this case takes place, and the selenite or baroselenite are reproduced. Hence the former method is *in general* the safest.

87. The alkaline solution should be duly evaporated if too aqueous, and saturated with nitrous acid, even to a slight excess; the siliceous part of the stone will thus be precipitated frequently in a gelatinous form; and, to hasten its precipitation, it should be heated to 180°, and gradually evaporated to a considerable degree; some argill also taken up by the alkali, often thus is deposited. The neutralized liquor should then be filtred, the deposit washed, and dried, and the filtred liquor essayed for vitriolic acid, as in No. 37.

88. The deposites, No. 87, may consist of silex and argill, which are best separated by boiling in the vitriolic acid, and precipitating the solution by mild volatile alkali; the argill thus found, to be dried, heated to redness for half an hour, and weighed, or essayed, for jargonia, as already mentioned; the silex also to be heated, and weighed, as before shewn.

89. We now proceed to the filtred mass, No.

86; this may consist of mild calx, stronthian, barytes, magnesia, argill, jargonia, adamantine, besides some remains of silex, with calces of iron, manganese, or nickel, or some undecomposed part of the original stone.

90. To separate these, or as many of them as exist in the stone, treat the whole with aqua regia, formed of two parts marine, and one part nitrous acid, in a retort, and boiling heat, repeatedly cohobating, or adding fresh acid, until the whole, or nearly the whole, if possible, is dissolved; what escapes solution may be either silex or adamantine, which may be decided by its fusibility or infusibility with fixed alkalis. If Sydneia be suspected, it may be discovered by its solution in pure marine acid, precipitation by water, and other tests of that earth. If any considerable part of the stone has escaped decomposition, it should again be torrefied with fixed alkalis.

91. The soluble earths being thus held in solution, the colour of the solution is to be considered; if yellowish, it probably contains iron, and no other, or but little of any other metallic substance; if brownish, probably manganese; if greenish, possibly nickel, or copper; if bluish, copper.

92. To distinguish whether the greenish colour proceeds from nickel, or copper, supersaturate a portion of the solution with caustic volatile alkali; if a blue colour does not arise, the colour must be from iron; but if the colour changes blue, it must be from copper or nickel; if from copper, a clean polished iron will precipitate the copper, but, if from nickel, it will be of no effect; besides, the calx of nickel will recover its greenish colour as soon

as the volatile alkali is exhaled, whereas that of copper will not.

93. If the solution contains no other metallic substance but iron, or iron and manganese, we may precipitate these by caustic volatile alkali; the precipitate filtred, washed, and heated to redness, should be repeatedly treated with nitrous acid, evaporated to dryness until the calces become thoroughly oxygenated, and, finally, the argill and magnesia that may exist in the precipitate are to be re-dissolved, and separated from the metallic calces by dilute nitrous acid, and from each other, as shewn from No. 19 to 29 inclusively.

94. The calces of iron and manganese are next to be separated; to effect this, let them be boiled in a concentrated lye of caustic vegetable alkali, which will take up the manganese, and not the iron; or let them be well mixed with eight or ten times their weight of pulverized nitre thrown into a crucible, and kept in fusion for one hour; pour the melted mass on a stone slab, leaving the iron at bottom; let the melted mass be pulverized, and thrown into a glass vessel filled with water; it will exhibit various colours, and in a few days subside in a brown mass; pour off the filtred water, and treat this brown mass with dilute nitrous acid, adding sugar, from time to time, or, what is still better, sulphureous acid, the calx of manganese will soon dissolve, precipitate the solution with mild soda, and weigh the white precipitate, gently dried, of which 180 grains denote 100 of the regulus of manganese; the weight of iron is to be determined as in No. 30.

95. If the solution contains other metallic

substances, it seems best, after expulsion of excess of acid, and sufficient dilution, to precipitate them by crystallized Prussian alkali, made as directed in the sequel, the quantity employed should be known, and noted; if the precipitation be slow, the solution should be warmed, or even heated nearly to boiling, spirit of wine being added, and often filtred. I shall suppose the precipitate, now obtained, to contain the different metallic substances, it should be washed, and the first washings added to the solution, as these washings contain part of the solution of the earths entangled in the precipitate, but when the washings cease to be acid, or when it is perceived that, when mixed with the solution of iron they produce a blue, they should cease, otherwise much of the precipitate would be carried off. When washed, it should be thoroughly dried, heated to redness, and weighed.

96. In this state the calces supposed to contain nickel, cobalt, and copper, are to be treated with caustic volatile alkali, which will turn blue, with the calces of copper, or nickel, and gradually extract them; to be certain that the whole of the nickel is separated, the precipitate should be again dissolved in the nitrous acid, the solution evaporated to dryness, weighed, and repeatedly treated with caustic volatile alkali, as long as it assumes a blue colour.

97. To separate the calces of copper and nickel, the volatile alkaline solution should be duly saturated with any acid.

98. If there be any cobalt in the solution, it would be precipitated during the saturation.

99. The neutralized solution should be then divided into two equal portions; into one of

which clean polished iron plates should be immersed; on these the copper contained in that portion of the solution will be deposited; this should be scraped off, and the operation continued as long as any copper remains; as these deposits, however, are contaminated with iron, they should be re-dissolved in nitrous acid, the solution evaporated to dryness, and again treated with caustic volatile alkali, which will take up the calces of copper singly; the alkaline solution evaporated to dryness, and the residuum heated to redness for half an hour, is the true weight of the calx of copper.

100. The second portion of the neutralized solution should then be evaporated to dryness, heated in the same manner, and weighed: from this weight subtract that of the calx of copper found in the last process, the remainder gives the weight of the calx of nickel contained in the second portion, which doubled gives that of the nickel in both portions, as the weight of the copper doubled gives the whole of that of copper.

101. The residue of the calces left by the caustic volatile alkali, No. 96, containing either iron, or iron and manganese, is to be treated as in No. 94; but, from the weight of the iron, we must subtract that of the calces contained in the Prussian alkali employed, of which we shall presently treat.

102. We now return to the solution, No. 95, which we suppose cleared from all metallic substances, but *possibly* containing all the earths (though, if the metallic substances were precipitated by caustic volatile alkali, the argill and jargonia would also be separated). Not that *all* these earths have ever been found toge-

ther in any stone, but as three or four of them indiscriminately taken often have, it is necessary to give a general method of discriminating and severing them; it were best, however, to institute small essays of each, to find which of them should be excluded from attention. Thus, if vitriolic acid, instilled into a portion of the solution, does not, after 10 or 15 minutes, cause a precipitate, we may be assured that neither barytes nor stronthian exist in it; and if, even after evaporation of the essayed portion, no precipitate appears, calx also may be excluded. So, if caustic volatile alkali causes no precipitate, argill and magnesia may be excluded from the solution; if it does cause a precipitate, let this precipitate be re-dissolved, and again precipitated by mild volatile alkali, and dry it well; if then it easily dissolves in marine acid, it is magnesia, and argill may be excluded; but if not it is argill, and magnesia may be excluded*. But if all these be found, as they often are, operate as follows:

103. Dilute the solution pretty largely, and precipitate the barytes, stronthian, and calx, by adding vitriolic acid as long as any precipitation appears; filtre this off, wash it; it will probably contain only vitriolated barytes and stronthian.

104. Evaporate the solution still farther, and add a few drops of vitriolic acid; if a precipitate then appears, it is vitriolated calx; add the vitriolic acid until this also ceases; filtre, and wash the matter on the filtre with dilute

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* Set aside some proportionate part of the solution, as one-eighth, or one-tenth, for such essays to be afterwards brought into the general account.

spirit of wine; evaporate still farther, more selenite will appear, which is to be filtred off, washed, and dried, as the former product, and at last heated and treated as in No. 10.

105. The washed mass, 103, should then be essayed for selenite, by pouring on it 500 times its weight of water, heated to 180; if this affords no precipitate with stronthian lime-water, we may be assured it contains no selenite; if it does, the selenite should be washed off.

106. The vitriolated mass, 103, containing nothing but vitriolated barytes or stronthian, or both, should then be treated as shewn from No. 57 to 59 inclusively.

107. The solution, No. 103, can now contain nothing else but magnesia and argill; these are, therefore, to be precipitated by mild volatile alkali, and separated, as shewn from No. 21 to 30.

§ VIII.—*Of the Prussian Alkali.*

The Prussian alkali is an agent of great importance, as it is an infallible test, not only of metallic substances in general, held in solution by any unmetallic acid (platina excepted), but even of the species and weight of that metal, if single, and the alkali properly conditioned.

To answer these purposes, it must be carefully prepared and properly applied; otherwise it will not only precipitate metals without their characteristic colours, or any designation of their weight, but also earthy substances, and particularly the barytic and the argillaceous.

To apprehend the reasons which determine the preference of one among the many preparations that have been hitherto devised, it is necessary to state a few circumstances relative to its general nature and mode of action, which have not yet been sufficiently developed.

Prussian, or prussiated alkali, formerly called the phlogisticated alkali, is an alkali united to a particular tinging substance by the intermediation of iron, calcined indeed, but only to that degree that does not prevent it from still being magnetic.

This tinging matter is itself an acid of the volatile kind, and of a very peculiar nature; for, though it seems to have a greater affinity to alkalis and earths than to any metal, yet it unites to them much more difficultly when in its free state, and adheres to them more feebly than to metallic substances, which I suspect arises from its being more condensed in the latter than in the former. When united to alkalis it is separable from them by the mere action of solar light, and also by a heat not exceeding 110°, or even a lower, in a longer time.

Metallic substances united to this acid are called prussiated metals.

Alkalis and earths extract this acid imperfectly from prussiated metals; but, when once united to this acid, they have a strong affinity to the metals whence they received it, and thus form triple salts, or rather saline compounds, called prussiated alkalis, or prussiated calx, &c. Prussiated alkalis, to whose consideration I now confine myself, are capable of crystallization (except the volatile), and soluble in three or four times their weight of water, in the temperature of the atmosphere; moreover, if not overloaded with iron, the metal to which they are commonly united, they are not readily decomposed by acids without the assistance of heat, or digestion in large quantities of the stronger acids.

On the other hand, iron (or rather its calces) forms, with the Prussian acid, compounds of two different kinds; the one fully saturated, the other unsaturated.

Calces of iron, thus circumstanced, present different colours; the fully saturated, a deep blue, and intermediate gradations of saturation, corresponding shades of blue; the unsaturated are yellow; when both are mixed they afford a green.

The unsaturated calces have a strong affinity to the quantity of Prussian acid requisite to saturate them; they are also soluble in common acids; but, if the common acids are not in sufficient quantity to dissolve the whole of them, the Prussian acid expelled from the dissolved part unites to the undissolved part, and converts this by saturating it into a blue calx; the blue calx is very difficultly decomposed by any acid, even the strongest, in the temperature of the atmosphere.

Alkalis and earths unite with both sorts of calces, but most strongly with the blue, yet before they can unite with either, they must themselves be impregnated with a portion of the Prussian acid, of which they strip them, as already said.

Hence when an alkali or earth is digested with a blue calx, it first strips a part of it of its saturating proportion of the tinging acid, and thus converts that part into the yellow calx, it takes up not only a portion of blue calx, but a still larger of the yellow calx. Now, to expel from the alkali this yellow part, which adheres more weakly to it than the blue, is, or ought to be, the object of all purifications of this test. If to an alkali, which contains a large proportion of this yellow calx, an acid be added, the precipitate will nevertheless be blue, because that part of the tinging matter that was more immediately united to the alkali quits it, and, joining the yellow calx, renders it blue.

I now proceed to examine the preparations of this test, that have been most frequently used in mineral analyses.

The first, and original compound of this sort, is that which is called the blood lye, being formed by the calcination of dried blood, with fixed alkalis. In this compound the tinging matter, accompanied with a small proportion of the calx of iron, is combined with the fixed alkali; but the high degree of heat in which the union takes place, and the small proportion of iron, prevents the alkali from being perfectly saturated, or, at least from being so, firmly and durably; besides, in the alkali usually employed, there is a contamination of vitriolated tartar, or vitriolated soda, some coal from the blood, with volatile alkali, and sulphur resulting from the mixture of the coal and the vitriolated salts, during ignition.

This, therefore, is an improper test; its unsaturated or feebly saturated part decomposes solutions of earths, particularly when they contain an excess of acid, as those of alum and barytes always do; the vitriolated salts also precipitate barytic, strontbian, and calcareous earths; these latter invisibly, if the solution be dilute. This lye, poured on a solution of iron, produces a greenish precipitate; but an acid, poured on the precipitate, turns it blue, by dissolving the yellow calx, produced either by the action of the unsaturated part of the alkali, or owing its colour to imperfect saturation with the tinging matter.

Hence the common Berlin blue of the shops is produced by the mixed solutions of vitriol of iron and of the alum by the blood lye; for the acid of the alum neutralizes the unsaturated part of the blood lye, and also that which might be feebly impregnated with the tinging matter, and hence the precipitate is blue.

It is plain, therefore, that the Berlin blue, so I call the Prussian blue of the shops, is not pure prussiated iron, but a mixture of this with embryon alum; that is, with alum which is barely stripped of its excess of acid, together with coal, sulphur, and other impurities of the blood lye.

Macquer first discovered that prussiated iron, or Berlin blue, might be stripped of the tinging matter by digestion with alkalis; and that these, when saturated, do not decompose saturate solutions of any earth; though, by means of a double affinity, they decompose and precipitate metallic solutions; an alkaline lye, thus saturated with the Prussian acid, or prussiated iron, is called Macquer's lye or test.

It is to be remarked, however, that though an alkali may thus be neutralized, it will not long continue neutral, because it takes up much of the yellow calx (which originates from the heat necessarily employed to impregnate the whole of the alkali); and this calx, adhering lightly, soon falls in the form of a blue calx, particularly if exposed to the air, from which the alkali may derive the aërial acid; so also mineral acids, or even weaker acids, decompose it, if not immediately, at least after a few hours, an effect which has often been falsely ascribed to the iron contained in those acids; hence earthy solutions that contain an excess of acid, as those of alum and barytes, are soon precipitated by it; yet if these solutions contain a large excess of acid they may escape precipitation, as, after saturating the weakly combined part of the alkali, enough of the excess may still remain to keep the earths in solution, but they will assume a blue colour, from the precipitation of the yellow calx, as already explained. This lye also takes up the sulphur, coal, and, by the washings, part of the tartar vitriolate and earth of alum contained in the Berlin blue, for which reason it will always precipitate barytic or stronthian solutions visibly, and those of calx, though perhaps invisibly, by reason of the greater solubility of selenite, and hence it is a bad test for metals.

Baumé endeavoured to remedy these defects, by adding distilled vinegar until the lye ceased to deposit a blue calx; but, as the action of this weak acid must be exerted some hours, and even days, before it can precipitate various gradations even of the yellow calx, it is impossible to determine its quantity with precision; if too little be added, the lye still continues defective; and if too much, this, after many days, or perhaps weeks, will loosen the union of the blue calx, by expelling from the alkali that portion of the tinging matter necessary to keep it in the state of a blue, and leaving it for a while only that which retains a yellow calx united to the alkali, and thus leaves it in a short time as imperfect as at first; besides, the vitriolic contaminations still remain.

Mr. Bergman's lye is the same as that of

Macquer;

Macquer; the proportions only being more accurately defined, for the purpose of subsequent correction. His alkali is formed by the detonation of equal parts nitre and cream of tartar, and, consequently, nearly caustic. This he dissolves in about a pint of water, and digests with four times its weight of Berlin blue, gradually added until it ceases to be discoloured, supplying it with water, in proportion to the quantity evaporated; and, lastly, boiling the whole for half an hour. This lye it is evident takes up the same impurities as the former, and is equally defective.

Others have prepared this test by saturating lime with the Prussian acid; but, as it is decomposed by the mere action of the vitriolic acid, it is frequently fallacious, not to insist on other defects.

Others prepare it by saturating volatile alkali with the tinging matter; this, if it could keep always homogeneous, would answer remarkably well. I omit various other methods of purification that have been devised, as they have not been employed in mineral analysis. I shall only remark, that almost all of them leave so much prussiated iron combined with the prussiated alkali, as totally to disguise the colours of the metals precipitated by them. In general, any preparation of this test that contains, when in a dry form, more than 80 per cent. of prussiated iron, will disguise the colour of most other metals precipitated by it; even a smaller quantity will produce this effect if it contains the yellow calx. Now, by Westrumb's experiments, Macquer's prussiated alkali crystallized affords 40 per cent. of prussiated iron, and after Baumé's purification 38; Bergman's purified by spirit of salt 28; Fourcroy's 31; Scopoli's 27; Giovanetti's 24; Brugnatelli's 24; Struvius's 22; Klaproth's 22. I say affords, for, in fact, the iron they contain is not fully prussiated until it and the tinging matter are expelled from the alkalis by the supervening acid.

The same able and industrious chemist has shewn that prussiated iron, well washed and dried, contains very nearly half its weight of the tinging matter; and it will presently be seen that 100 parts vegetable alkali take up 46 of the tinging matter.

Of Klaproth's Test, and its Application.— 1. Prepare a pure vegetable alkali, by gradually projecting a mixture of equal parts purified, nitre and crystals of tartar into a large crucible heated to whiteness; when the whole is injected, let it be heated to whiteness for half an hour, to burn off the coal.

2. Detach the alkali thus obtained from the crucible, reduce it to powder, spread it on a muffle, and expose it to a white heat for half an hour.

3. Dissolve the calcined salt in six times its weight of water, and filtre the solution while warm.

4. Pour this solution into a glass cucurbit or receiver, heated to 170 or 180°, in a sand furnace, and then gradually add the best Prussian blue in powder, injecting new portions according as the former becomes grey, and supplying water as fast as it evaporates; continue until the added portions are no longer discoloured, then increase the heat to 212°, for half an hour.

5. Filtre the lye, thus obtained, and saturate

it

it with vitriolic acid, moderately diluted; a precipitate will appear when this ceases; filtre off the whole, and wash the precipitate.

6. Evaporate the filtred liquor to about one quarter, and set it to crystallize; after a few days, yellowish, cubic, or quadrangular crystals will be found mixed with some tartar vitriolate, and calx of iron; pick out the yellowish crystals, lay them on blotting paper, and re-dissolve them in four times their weight of cold water, to exclude the tartar vitriolate.

7. Essay a few drops of this solution with barytic lime-water, and add some to the remainder if necessary; filtre off the solution, and set it to crystallize for a few days; thus the barytic lime, if any should remain, will be precipitated; if the crystals now obtained, are of a pale yellow colour, and discover no bluish stripes when sprinkled over with marine acid, they are fit for use; but, if they still discover bluish or green streaks, the solutions and crystallizations must be repeated.

8. These crystals must be kept in a well-stopped bottle; and I think it right to fill it with spirit of wine, to preserve them from the air, as they are insoluble in spirits.

9. Before they are used, the quantity of iron they retain (and which I therefore call their *retent)* should be ascertained, by heating 100 grains to redness for half an hour in an *open* crucible, the Prussian acid will be consumed, and the iron will remain in the state of a reddish brown magnetic calx, which should be weighed, and noted; if the calx be black, it will weigh considerably more than it should, and must be calcined anew; the red calx is half the weight of the Prussian blue, afforded by

the Prussian alkali; its weight must be subtracted from that of metallic precipitates formed by this test. Hence the weight of the crystals, in a given quantity of the solution should be noted, that the quantity employed in precipitation may be known.

Remarks on the Analysis already made.—It has been to many matter of much surprize, that the same stone, analysed by different eminent artists, has been found to contain either different ingredients, or, at least, different proportions of the same ingredients; of such differing results, various examples have thence been seen in the foregoing chapters; several have been led to suspect, that chemical analyses have hitherto been either very imperfect, or totally useless.

The opinion, however, of the inutility of developing the principles of which any compound consists, is too absurd to deserve attention; who can deny the properties of a compound are either the results of those of the ingredients of which it consists, modified by the proportion of those ingredients, or new ones resulting from, and grounded on, particular proportions of those ingredients, neither of which circumstances can be determined otherwise than by analytic investigation?

The imperfection of many of the analyses hitherto made must indeed be allowed, though the instances are not so frequent as have been imagined; several stones that have been denoted by the same name are in reality different, and have been found to be so, even by an attentive consideration of their external characters; for instance, the different sorts of felspar, shorl, actynolites, &c. no wonder, therefore, that their analyses should present different results.

The real imperfections of many analyses have arisen from various causes; as, first, our ignorance of some of the simple earths, thus stronthian has hitherto been confounded with barytes, or perhaps with calx, jargonia with argill, and adamantine with silex; Sydneia has as yet been scarcely noticed: this source of error, inevitable in an art sprung up within these twenty years, will necessarily daily diminish; analysts will become more circumspect in determining the nature of any substance, before two or three of its most essential properties will have been ascertained.

Secondly, Many deceptions have arisen from the erosion of mortars, during trituration, many from the mixture of the earths of crucibles during calcination.

Thirdly, The difference of the proportion of ingredients in many substances is often more apparent than real, arising entirely from the various degrees of desiccation that have been employed by different analysts, and sometimes by the same; this point is so important, that I shall examine it more particularly, hoping that some of our most eminent artists may determine some precise degree, and the term of its duration that should in future be always observed.

Mr. Bergman, in his essay on the analysis of mineral waters, treating of the weights of earths, mentions no precise limits or degree of heat to which they should be exposed; in his treatise on metallic precipitates, he requires indeed these to be dried, first in a gentle, and at last in the heat of boiling water for five minutes; but estimating the weight of different salts in his essay on mineral waters, he takes them in their crystallized form, and consequently dried in a low heat.

Siliceous earth he desires should be barely dried*, I suppose in the temperature of the atmosphere.

With respect to *calx*, *argill*, and *magnesia*, in his treatise on mineral waters, he submits to the operator, whether the mass that contains them should be calcined or not†, and then weighed; he separates the magnesia and calx from the containing mass by distilled vinegar; to obtain their joint weight, he requires the mass from which they were extracted to be washed, *dried*, and weighed, and their weight discovered by the loss of weight of the dried residuum. Here it is plain the residuum must again be calcined, to discover the weight it had lost, as in a lower heat this must vary considerably; but how the weights of the calx and magnesia, separately, are to be determined, he does not clearly indicate. Nor in his essay on gems is he more explicit, defining the weight of the calx and magnesia only by the quantities of gypsum or Epsom they may yield; that of Epsom must vary considerably in a high heat. In his analysis of lythomarga he directs the argill to be barely *dried*‡.

Hence we see he follows no certain rule in estimating the quantities of argill, magnesia, and calx; these last he wishes rather to determine by the quantity of saline matter they yield when converted into salts and crystallized*, the quantity of earth in these crystals being already determined; but it is well known that crystallization scarcely ever affords the whole of the substances contained in the solution; with regard to Epsom, in particular, its weight varies with the temperature of the water in which it was crystallized, and the heat and moisture of the air in which these crystals are dried; this method is therefore very insecure.

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* 2d Bergman, 92. 4th Bergman, 148.

† 1st Bergman, 123.

‡ 4th Bergman, 151.

Moreover, Mr. Westrumb found that 69,75 grains of siliceous earth, precipitated from *liquor silicum* (silicited alkali) well washed and dried, weighed no more after exposure to a red head than 61,5, and consequently lost 11,8 per cent.†: whether this loss of weight proceeds from some inflammable matter, or from water retained, it is equally certain that desiccation in the heat of the atmosphere does not determine the real quantity of this earth; on another occasion he found silex weighing at 112°, 25,5 grains to weigh after a red heat only 22‡; the difference is about 13,7 per cent.

By this remark I am far from meaning to detract from the merit of this truly respectable philosopher, so far indeed that I freely own, that, in the few analyses I made myself, I fell into the same mistakes; such errors are incident to the first attempts in every art.

With respect to argill, the difference of weight arising from different degrees of desiccation is enormous. Mr. Wenzel found that argill precipitated by mild soda, and weighing when dried in the air 140 grains, might by ignition continued for two hours be reduced to 56, that is, to less than one half its weight. Knock found that argill dried at 66° of Fahrenheit and 51 of Saussure, and then weighing 32 grains, lost by ignition continued for one hour 12 grains, that is, 37,5 per cent.* Westrumb observed, dry argill, weighing 16,625 grains, to weigh after a long continued calcination only 10, it lost therefore above 40 per cent.†; but this had been precipitated by caustic volatile alkali; in another experiment, argill that had been precipitated by mild soda, and consequently taken up fixed air, weighed when dry 30 grains; but, after long continued ignition, he found it reduced to 10, and consequently had lost two-thirds of its weight‡. Here then a distinction appears, which should not be neglected; in my own experiments I generally found argill precipitated by mild volatile alkali, and dried in a heat of 70°, to lose, in a red heat continued for half an hour, about 36 per cent. and unaërated argill, about 30 per cent.; much, however, depends on the previous drying in air of different degrees of moisture; for, Mr. Klaproth found aërated argill well dried in a heat exceeding that of the atmosphere, to lose by two hours calcination only 30,5 per cent.§

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* 1st Bergman, 124.

† 2nd Chy. Ann. 1790, p. 218.

‡ 2nd Bergb. 29.

Weigleb for some time followed the method of Bergman; previous to the year 1786, he contented himself with barely drying his earths;

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* 2nd Chym. Ann. 1789, p. 24.

† 2nd Bergb. 30.

‡ 2nd Bergb. 32. Knock denies the distinction; but it is evident he was somehow deceived.

§ 8 Berl. Beob. 67.

earths[*]; but, since that period, he seems to have generally ignited them, though probably not long enough[†].

Westrumb has also constantly determined the weights of his earths by ignition, and in many instances has shewn the differences of their weights when heated in the usual manner, and after ignition; he has proved that even ponderous spar requires ignition to dry it perfectly; but he does not seem to have regulated the time they should be exposed to a red heat.

Dr. Withering dried his argill in a low red heat for 10 minutes; the other earths he seems to have barely dried in the heat of the atmosphere. Klaproth constantly ascertains the weights of *all his earths*, after low ignition for half an hour. As in most stones the component earths are in an exceeding dry state, and, if not, the weight of water and air they contain should be ascertained previous to their analysis; it should seem that the desiccation occasioned by ignition is that which approaches most to their natural state, and consequently should always be obtained.

4. The difficulties accompanying the application of the Prussian test have occasioned many errors.

Weigleb constantly employed the blood lye[‡]; this is scarce ever perfectly saturated, and, at least after a short time, precipitates earths as well as metals; also, by reason of the vitriolic acid it contains, calx cannot escape it;

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[*] 11 Nev. Entdeck. And 2nd Chym. Ann. 1784, p. 146. 1st Chym. Ann. 1785, p. 25, 249, 394.

[†] 1st Chym. Ann. 1786, 117. 1st ditto, 1787, 19. And 1788, 49.

[‡] 1st Crell. Beytrage, 55.

hence perhaps he has detected none where others have found it; besides, he makes no deduction for the iron contained in this alkali.

Mr. Bergman informs us, the Berlin blue he employed in making his Prussian alkali contained 23 per cent. of prussiated iron; the remainder being argill, or embryon alum.

Of this Berlin blue, he employed in making a quart of his lye 960 grains; and since 100 of the blue contain 23, 960 must have contained 220,8 of prussiated iron.

But prussiated iron only contains half its weight of the tinging matter, then his prussiated iron contained 110,4 of prussiated acid, and 110,4 of calx of iron.

A quart of his lye he computed to contain 240 grains of alkali, and 110,4 of Prussian acid, and 16 docimastic pounds (that is, 0,6 grains multiplied by 16) =9,6 of prussiated iron. Or four docimastic pounds of this iron (that is, 0,6 multiplied by 4 = 2,4 grains) for every 60 grains alkali, as 240 grains alkali make up 400 docimastic pounds.

He then tells us, that a precipitate made by this lye, dried, I should suppose, in a heat of 212° for 5 minutes, contains one-sixth of its weight of metallic iron, deducting 2,4 grains for every 60 grains of alkali employed in making the precipitate. He does not tell us whether this quantity should be deducted from the sixth part thus found, or from the whole precipitate by the division by 6; or, in other words, whether it should be deducted from the quotient or the dividend; in his second volume, p. 435, he seems to require it should be deducted from the quotient, though, in reason, it should rather be deducted from the dividend, as he tells us it is undecomposed Berlin blue; however this may be, in his Analysis of Lythomarga, vol. iv. p. 149, and in that of Pouzzolana, vol. iii. p. 193, and his Treatise on Gems, he totally omits this deduction.

Let us now see how, on Mr. Bergman's statement, a weight exceeding five times that of the metallic iron precipitated could accrue. 100 grains of metallic iron, being reduced to a calcined state, weigh 140 nearly; these, when prussiated, should weigh 280 grains, as has been shewn. Again, 240 grains alkali, take up, by Bergman's account, 110,5 of the tinging matter, then 304 of alkali would be requisite to take up 140 of the tinging matter, the quantity required to prussiate the 140 grains of iron. But every 60 grains of alkali deposit 2,4, therefore 304 should deposit 12,16, then the weight of the precipitate should be 280 + 12,16 = 292,16: 307 remain to be accounted for, and must by him be deemed to proceed from the argill and coal taken up by the alkali, and some alkali retained, besides water*. Mr. Bergman does not strictly adhere to the position, that 100 grains iron, separated by the Prussian alkali, forms a precipitate weighing 600 grains; for, vol. ii. p. 392, he reduces it to 590. Mr. Gadolin, in a masterly defence of Bergman, published in the Swedish Memoirs for 1788, informs us, that Bergman dried his precipitate in the temperature of the atmosphere; and, according as that was warm or cold, moist or dry, the weight of the precipitate varied from 602 to 595, but, when dried in the temperature of 160 or 180° Fahrenheit, he constantly found it to weigh 540 grains. The true account seems to be this: 304 grains alkali are requisite to take up the tinging matter of 280 grains of Prussiated iron, the alkali should then weigh $304 + 140 = 444$ grains, but 80 grains of the alkali saturated in this manner take up 20 of calx of iron, as Mr. Westrumb has demonstrated, consequently 444 should take up 111; then the precipitate should weigh $292 + 111 = 403$, the remainder may be argill, coal, and moisture.

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* But principally from the *retent*, which far exceeds 12,16 grains, as Westrumb demonstrates.

I make no doubt but Bergman and Gadolin found the results as they have stated them; but it is plain they make use of the same sort of Berlin blue in Prussiating their alkali; another species of Berlin blue, containing more or less argill, charcoal, or Prussiated iron, would certainly produce a variance in the *retent;* and hence it is that every other chymist, who has examined a Prussiated alkali, formed like that of Bergman, found the quantity of calx of iron it retained very different, and if the *retent* be variable, the weight of the precipitate, dried how it may be, must also be variable, and consequently this mode of determining the weight of iron in any fossil, is not to be depended upon.

1st, Dr. Withering employed an alkali formed by the detonation of nitre and crystals of tartar, just as Bergman did, and boiled it over Berlin blue until it was saturated. He does not, indeed, tell us the proportion of Berlin blue to the alkali; neither is it material, as Gadolin owns, for he found no difference when the alkali was one-fourth, one-eighth, or even half*;

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* Schwed. Abhandl. 1788, p. 115.

and,

and, having added this Prussiated alkali to a solution containing iron, he found the precipitate dried in the temperature of the atmosphere to weigh 66 grains; this then, according to Bergman, ought to contain 11 grains of metallic iron, and, if we are to make a deduction of the Prussian blue contained in the alkali, still less; yet Dr. Withering having calcined the precipitate in a low red heat, found the whole to amount to 31 grains and a half, and after deducting 11 and a half, which were the retent of the Prussiated alkali, the quantity in the fossil amounted to 20 grains, but this being in a calcined state, must be farther reduced in the proportion of 140 to 100, and then we have 14,29 of metallic iron instead of 11.

Again, it being established that Prussiated iron is in a calcined state, and contains its own weight of the tinging acid, and that 240 grains of the alkali take up the tinging acid of 221 grains of Prussiated iron, and consequently 110,5 of the tinging acid, it follows that 100 grains of the alkali take up 46 of the tinging acid, and, *vice versa,* 46 parts of the tinging acid require for their saturation 100 of vegetable alkali; if so, the 20 grains of calx of iron found by Dr. Withering took up 20 of tinging matter, and this quantity of tinging matter required 43,48 of alkali, consequently its *retent* ought not, according to Bergman, to amount even to 2,4 grains of Prussiated iron; yet the Doctor found it to amount to 11,5 grains of calx, which when Prussiated amounted to 23 of Prussiated iron; here we have the weight of the precipitate clearly accounted for, 40 grains being the part of the Prussiated iron contained in the fossil, and 23 in the *retent* equal to 63; the three remaining grains being argill or moisture

2nd, Mr. Westrumb formed a lye of the same sort as Bergman, by saturating eight ounces of vegetable alkali with the tinging matter of the Berlin blue. This lye he evaporated, and found to yield 10,81 ounces of Prussiated alkali*; it should certainly yield much more (for since 100 grains of alkali take up 46 grains of the tinging acid, 8 ounces = 3840 grains, should take up 1766 of the tinging acid, and consequently weigh 11,66 ounces), had it not been that much of the natural salt thus formed is decomposed during the evaporation, as Mr. Westrumb himself has shewn; for, two ounces of this salt being re-dissolved, afforded one ounce and a half, and 12 grains of iron were deposited; now 100 parts of this salt, being decomposed by vitriolic acid, afforded him 40 parts of Prussiated iron, and when decomposed by calcination 19,3 of calx of iron. He also found, that after a few minutes the lye decomposes solutions of alum, and other solutions that contain an excess of acid.

Hence it sufficiently appears, without adducing other testimonies, that this test, thus prepared, is productive of many errors; and that Mr. Bergman's computation of the quantities of iron is subject to two errors, which in some cases correct each other, one which makes the quantity of iron too small, by reckoning it only one-sixth part of the precipitate, and another that makes it too great, by making too small an allowance for the *retent* of the Prussian alkali; however, sometimes one, and sometimes the other, predominates; it should also be remembered, that the quantities he indicates denote iron in a metallic state, unless the contrary be expressly mentioned.

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* 2nd Westrumb, 155, 156, &c.

The analyses of Klaproth and Westrumb are free from these errors; lastly, in those cases where stones are torrefied with aërated alkalis, it is difficult to know whether the calx and magnesia found in them were originally aërated or not, particularly when they abound. Bergman is guided by the excess or defect of weight.

END OF VOL. I.

Printed by B. M'Millan,
Bow Street, Covent Garden.